Essays on Financial Contagion and Regime Shifts

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Abstract

Essays on Financial Contagion and Regime Shifts

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This study reexamines the Asian stock market contagion by employing a dynamic multivariate GARCH model. Based on a commonly held definition, contagion is defined as a significant increase in comovements between asset returns across markets. By analyzing the correlation coefficient series, this paper identifies two phases of the Asian crisis. The first phase shows an increase in correlation (contagion) and the second phase shows continued high correlation (herding). Statistical analysis of correlation coefficients shows both the level and the variance shifts, providing evidence of contagion effect and casting some doubt on the benefit of international portfolio diversifications during the crises.

This study further explores the contagion effects through sovereign rating changes during the crisis, i.e. how the sovereign rating changes in one country affected its own stock markets and stock markets in other Asian crisis countries. Using the sovereign rating changes announced by Standard & Poor's during the period from 1990 to 2003, the panel estimation finds that overall, rating changes do not show strong evidence of a pro-cyclical tendency during the crisis period. However, the contagion effect was found to exist in the sense that rating changes in one country affect the stock markets in other crisis countries. During the crisis, the contagion effect was coming from the instances of upgrades; no comparable evidence has been found in the cases of downgrades. One possible

explanation is the market expectations in the downside of the market. Event study further confirms the contagion effects during the crisis period.

Lastly, this study contributes to the literature by studying the contagion effects from the currency markets to the stock markets. The non-linear relationship between exchange rate changes and stock returns is examined by using various specifications of Markov regime-switching models. The models endogenously distinguish two different regimes. The exchange rate exposure of the national stock returns is mainly through the real channel in tranquil period and through financial channel in volatile periods.

Chapter 1. Introduction

In 1997 and 1998, the economic and financial crisis hit many Asian countries and plunged some of the most rapidly growing and successful economies into financial turbulence and deep economic depression. A remarkable feature of the crisis is how rapidly it spread from one country to another in the region and further to Russia and some South American countries. Most of the Asian countries severely hit by the crisis had been pegging their currencies to the U.S. dollar or a basket of currencies in which the U.S. dollar dominated before the crisis. However, after several weeks of speculative attacks, the Bank of Thailand announced on July 2, 1997 a managed float of the Baht and called for IMF's assistance. Following the collapse of the Thailand Baht, the financial markets (including both currency markets and stock markets) of Southeast Asia faced increasing pressure, which was reflected in the managed floating of the currencies in the Philippines, Malaysia and Indonesia in late July and August 1997.

As the crisis deepened, panic spread among both foreign and domestic creditors and investors and the foreign exchange and stock market turmoil spread to the entire region, culminating in the collapse of the Korean won on November 17. During this period, even some more developed economies suffered from the turmoil, such as Hong Kong, Singapore, Taiwan, and Japan. Over the interval from July 2 to December 31, the domestic equity indices for Thailand, Indonesia, Malaysia, the Philippines, South Korea, Hong Kong, Singapore, Taiwan, and Japan dropped in the range from 9% to 70%, and the local currencies also depreciated against the U.S. dollar as large as almost 70% (except Hong Kong, which keeps its currency board exchange rate system). [1]

The turmoil in the financial markets in these countries led to capital flowing out of the region with billions of short-term bank loans recalled in the second half of 1997. The Asian crisis was followed by the Russian crisis as Russia government defaulted its debt in August 1998, and further by crises in Turkey, Brazil and Argentina. However, the Asian crisis is still the most severe one, in terms of how fast the crisis spread within the region and the number of countries involved. Within five months, eight Asian countries were affected. Before the occurrence of the Asian crisis, all these Asian economies had strong macroeconomic fundamentals and none of the agencies, such as IMF, World Bank, and ADB, had been able to foresee the impending event. Therefore this thesis is going to focus on how the shocks are transmitted across different financial markets among these Asian countries during the 1997-1998 Asian financial crisis.

The international transmission of financial market shocks has been a hot topic in the academic area since the Asian crisis. The word "contagion" has been used extensively after that to describe the significant increase in financial market comovement or linkages. In response to the contagion phenomenon, the empirical research has developed into two different paths.

The first path has focused on whether there are increases in market comovement of asset returns during the crises (e.g. King and Wadhwani, 1990; Baig and Goldfajn, 1998; Forbes and Rigobon, 2002; Corsetti et al., 2002). The second chapter in this thesis

[1] The drop in domestic stock returns for Thailand, Indonesia, Malaysia, the Philippines, South Korea, Hong Kong, Singapore, Taiwan, and Japan is 42%, 60%, 70%, 39%, 73%, 35%, 24%, 9%, and 28% respectively while the depreciation of local currency for these countries is 51%, 59%, 43%, 41%, 65%, 0.03%, 16%, 16%, and 13% respectively, versus the U.S. dollar.

is trying to reexamine the increases in correlation of stock returns in several Asian countries during the crisis by taking into account the heteroskedasticity issue directly. Chapter 2 contributes to the contagion literature by estimating the time-varying correlation coefficients and presenting some evidence of contagion effects. In addition, the source of contagion is investigated and identified during the sub-periods of the crisis.

Chapter 3, on the other hand, focuses on the second path, which examines the contagion effects through specific transmission channels. In the literature, papers focusing on different transmission channels find evidence in contagion effects (e.g. Van Rijckeghem and Weder (1999) using bank funds data, Froot et al. (1999) using portfolio flows, Basu (2002) using bond market data). However, only a few papers addressed the role of sovereign credit rating changes in transmitting shocks across stock markets. The sovereign rating downgrades during the crisis are often blamed to aggravate the crisis. This argument is tested using panel data from five most severely hit countries. Whether there are contagion effects due to sovereign credit rating changes in other countries is also examined.

As observed, the Asian crisis started with large devaluation of the Thailand baht and then spread to the financial markets in other countries. The contagion effects across different assets (currencies and stocks) are studied in Chapter 4. Regime switching model is used to endogenously determine different regimes and examines the different exchange rate exposures of the national stock returns at different regimes. Since the exchange rate systems in most of the crisis countries changed from the pegged system to the managed floating system during the crisis, the contagion effects from the currency markets to the stock markets are different.

Chapter 2. Empirical Analysis of Financial Contagion – Evidence from the Asian Markets

2.1 Introduction

During the Asian financial crisis, the financial markets in the crisis-hit countries displayed significant comovements and the financial shocks transmitted across the markets in a short time. This chapter focuses on whether there is financial contagion across these Asian countries, which has important implications for policy makers who concern the financial stability and investors who concern the risks involved in their investments.

However, there exists disagreement on whether there is contagion or not in the literature. Some studies show a significant increase in correlation coefficients during crises and conclude that there exists contagion effect (for example, Baig and Goldfajn, 1998). Others find that after accounting for heteroskedasticity, there is no significant increase in correlation between asset returns of two crisis countries, reaching the conclusion of "no contagion, only interdependence" (see Forbes and Rigobon, 2002; Bordo and Murshid, 2001; Basu, 2002).[2] However, Corsetti, et al. (2002), using a single factor model, find "some contagion, some interdependence" in their tests of financial contagion. In addition, papers focusing on different transmission channels find evidence of contagion effects (e.g. Van Rijckeghem and Weder (1999) using bank funds data, Froot et al. (1999) using portfolio flows, Basu (2002) using bond market data, Forbes (2000) using firm level data, Kaminsky et al. (2000) using mutual fund data).

[2] Forbes and Rigobon (2002) define *contagion* as significant increases in cross-market comovement. Any continued high level of market correlation suggests strong linkages between the two economies that exist in all states of the world, and is defined as *interdependence*.

By using a multivariate GARCH model on high frequency data in nine Asian countries, this chapter deals with the heteroskedasticity and endogeneity problems in the linear models used in the literature and derives the pair-wise time-varying conditional correlation series among the stock returns in the crisis countries. These correlation series identify various major events during the sample period and different phases during the Asian crisis. Furthermore, in order to examine the dynamic relationship among asset returns, a VAR system is established and then the variance decomposition analysis show which country has the most explanatory power of stock return variation during different phases of the crisis.

The major findings of this chapter are as follows. First, this study finds some evidence of contagion, in contrast with the strong conclusion “no contagion, only interdependence” in Forbes and Rigobon (2002) but consistent with the perceptions during the Asian crisis. Second, two different phases of the crisis can be identified. The first phase shows a process of increasing correlations from the start of the crisis to November 17, 1997 and provides evidence of contagion from the earlier crisis-hit countries to other countries. The second phase shows a high level of correlation from the end of 1997 to 1998 and provides evidence of herding behavior by the investors. Third, the sources of contagion during the different phases of the crisis are analyzed. In the early phase, Malaysia transmitted more shocks to the neighboring countries, while in the second, Hong Kong and Thailand seemed to have more influence. Last, the evidence from the Japanese stock market suggests that the contagion from the crisis countries to Japan started much later in 1998 and the magnitude was smaller, compared to that among the emerging economies.

The chapter is organized as follows. Section 2.2 reviews the literature on financial contagion during the crisis. Forbes and Rigobon's method is briefly introduced. Section 2.3 describes the data used in this study and explains different characteristics of correlation coefficients before and after the Asian crisis. The methodology of a multivariate GARCH model is presented in Section 2.4 and Section 2.5 explains the estimation results. Section 2.6 describes a VAR model and analyzes the results of variance decomposition. Section 2.7 presents conclusions and further extensions.

2.2 Literature Review

The research on financial contagion has developed into two paths. The first focuses on the theoretical modeling of the transmission channels of financial shocks during crises. The second stresses on econometric refinements and attempts to provide more updated empirical evidence of financial contagion based on correlation analysis.

2.2.1 Channels of Transmitting Shocks

In the contagion literature, there are several main channels through which shocks are transmitted due to investor behavior in financial markets (Pritsker, 2001). C*orrelated information channel* argues that if two countries have real links, such as trade-investment linkages or industry linkages, then negative information in one country may lead to asset selling and price declines in the other market, which is often amplified by information asymmetry (see von Furstenberg and Jeon, 1989; King and Wadhwani, 1990). The wake-up call hypothesis, however, does not assume any real linkages between countries (see Sachs et al., 1995; Wolf, 1999). It argues that if one country with certain macroeconomic characteristics, such as a weak banking sector, is discovered to be vulnerable to a currency crisis, then investors will reassess the risk of other countries with similar fundamentals even if these investors have not changed their risk tolerance.

The second channel is the *liquidity channel*. Since international investors hold portfolio positions in different markets, when they have a capital loss in one market, they have to sell assets in other markets not directly related with the crisis country to meet certain requirements, such as margin calls (Claessens et al., 2001; Forbes, 2000).

The third channel, the *cross-market hedging channel* was formally modeled in Kodres and Pritsker (2002) using a rational expectations model. They show that even if two countries have no common macroeconomic risk, their asset returns may still show strong comovement due to asymmetric information from different types of investors. In addition, Calvo and Mendoza (2000) demonstrate that globalization will increase two types of information frictions and exacerbates contagion due to information heterogeneity.

The fourth channel is the *wealth effect channel*. Kyle and Xiong (2001) formally model the wealth effect to explain the panic of hedge funds, banks and securities firms after the fall of the hedge fund Long Term Capital Management. The short-term convergence traders become more risk averse when the noise traders cause an unfavorable shock to asset prices. They are able to liquidate large amount of risky positions across their whole portfolio as their wealth decreases, resulting in large price volatility and correlation between different markets.

However, direct empirical tests of these channels are difficult due to lack of microstructure data regarding investors.[3] Therefore, many empirical studies of contagion effects turn to the study of asset return co-movement, which is a result of the above transmission channels and also observation during the crisis. In this study, contagion is defined as a significant increase in correlation between asset returns in different markets.

2.2.2 Correlation Analysis

Correlation analysis is important for diversification, risk management and the pricing of asset portfolios (Fong, 2003). Increased correlation during turbulent periods reduces the benefits of asset diversification and compromises the reliability of hedging operations based on historical correlations. It also undermines the risk management models that assume stable correlations. When correlation analysis is used to examine the existence of financial contagion, it also has policy implications for evaluating the role of international institutions. In the presence of liquidity crisis and its contagion, IMF intervention and dedication of massive amounts of money to bail-out funds could be justified (Billio and Pelizzon, 2003).

There have been tests of increases in correlation coefficients for changes in interest rates, exchange rates, stock prices, and sovereign spreads across different markets. However, there has not been consensus on whether such co-movements increase after a crisis. Some studies find significant increases in correlations between asset returns in the crisis countries (e.g. Baig and Goldfajn, 1998; Park and Song, 2001). Others argue that

[3] A companion paper by Chiang et al. (2003) looks at how sovereign credit rating changes affected the stock markets in the crisis countries. Sovereign credit rating changes in one country could trigger stock market decline in another country, especially during the turbulent period. This is consistent with the wake-up call hypothesis and cross-market hedging hypothesis.

this increase may be due to an increase in volatility (see King and Wadhwani, 1990; Forbes and Rigobon, 2002). Forbes and Rigobon (2002) (thereafter as F-R) formally propose a formula to correct correlation coefficients for heteroskedasticity. After accounting for that, the estimated correlation coefficients do not show significant increases. They claim that there is no contagion, but only interdependence. Some applications of this correction do find little evidence of contagion (e.g. Bordo and Murshid, 2001; Basu, 2002).

Since F-R make a strong argument and are the first to address the heteroskedasticity issue formally, I will use an example to illustrate their point. They assume that stock returns in two countries during "tranquil" times are linearly related:

$$r_{1,t} = \beta_0 + \beta_1 r_{2,t} + v_{1,t}$$

where $r_{1,t}$ and $r_{2,t}$ are stock returns in countries 1 and 2 at time t, respectively, and $v_{1,t}$ is a stochastic noise independent of $r_{2,t}$. The variance of r_1, covariance and the correlation between the two returns can be expressed as:

$$Var\ (r_1) = \beta_1^2 Var\ (r_2) + Var\ (v_1)$$

$$Cov(r_1, r_2) = \beta_1 Var(r_2)$$

$$\rho = Corr(r_1, r_2) = \frac{Cov(r_1, r_2)}{\sqrt{Var(r_1)Var(r_2)}} = \frac{\beta_1 Var(r_2)}{\sqrt{[\beta_1^2 Var(r_2) + Var(v_1)]Var(r_2)}} = \left[1 + \frac{Var(v_1)}{\beta_1^2 Var(r_2)}\right]^{-1/2}.$$

These expressions show that if a crisis occurs in country 2 with increasing volatility in its stock market, it should be transmitted to country 1 with a rise in volatility and correlation of two returns.

For this reason, F-R adjust the correlation coefficient as follows:

$$\rho^* = \frac{\rho}{\sqrt{1+\delta[1-(\rho)^2]}}$$

$$\delta = \frac{VAR(r_2)_h}{VAR(r_2)_l} - 1 \tag{2.1}$$

where ρ is the unadjusted correlation coefficient (depending on the high or low volatility period), ρ^* is the adjusted correlation coefficient (regardless of the volatility), δ is the relative increase in the variance of r_2, $VAR(r_2)_h$ and $VAR(r_2)_l$ are the variance of r_2 in high volatility period and low volatility period, respectively.

Later, Corsetti et al. (2002) point out that the linear relationship assumed in F-R ignores the country-specific component of the change in the variance of the second country's asset return. They establish a single factor model and develop a two-step conditional test for hypotheses of interdependence versus contagion. They find that there is some contagion and some interdependence. [4] However, a common problem encountered by these studies is that these tests are highly affected by the choice of window (Billio and Pelizzon, 2003). Also the choice of sub-samples conditioning on high and low volatility is both arbitrary and exposed to selection bias (Boyer et al., 1999).[5]

In this chapter, a new procedure developed by Engle (2002) is used to examine whether there is a significant increase in the correlation of stock returns. Using a

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[4] The single factor model may not be true in the case that Kodres and Pritzker (2002) suggest. The latter argue that even if two countries do not have a common factor, contagion effect may still occur due to cross-market hedging. In addition, the model in Corsetti et al. (2002) is still a linear model.

[5] Fong (2003) uses a bivariate regime-switching model by pairing the US stock market with four other major stock markets and allowing for correlations to switch endogenously as a function of volatility jumps of a particular country. It is found that the extent of correlation jumps is generally small and statistically significant for only Canada. However, it also admits that the model shares the same limitation as the previous literature in that it assumes one country (the US) to be the only source of volatility shocks.

multivariate GARCH model with time-varying conditional correlation,[6] it solves the heteroskedasticity problem addressed by F-R without having to divide the whole sample period into two sub-periods arbitrarily. It also avoids the endogeneity issue in many papers in the literature. For example, F-R assumes Hong Kong as the source of contagion. However, during the crisis news in each crisis country could trigger financial market turbulence in other neighboring countries. Using variance decomposition, this chapter further identifies the source of contagion at different stages of the crisis.

2.3 Data and Descriptive Statistics

The data collected from *Datastream International* are daily stock price indices from January 1, 1990 to March 21, 2003 for eight seriously affected Asian countries during the financial crisis in 1997 and 1998, namely Thailand, Malaysia, Indonesia, the Philippines, South Korea, Taiwan, Hong Kong, and Singapore. The stock indices used for these countries are Bangkok S.E.T. Index, Kuala Lumpur SE Index, Jakarta SE Composite Index, Philippines SE Composite Index, Korea SE Composite, Taiwan SE Weighted Index, Hang Seng Index, and Singapore Straits Times Index, respectively. Also included are two stock indices from industrial countries, Japan (Nikkei 225 Stock Average Index) and the United States (S&P 500 Composite Index). Japan was also affected by the Asian crisis, but at a much later stage and to a lesser extent. Whether there is financial contagion from the crisis countries to Japan and to what extent Japan's

[6] Another GARCH model with constant conditional correlation, proposed by Bollerslev (1990) and followed by Longin and Solnik (1995), can also be used to identify factors that affect the conditional correlation, but it can only deal with one factor at a time due to too many parameters.

stock market was affected are examined. The U.S. is included here mainly as a global factor.

Stock returns are calculated as first differences of natural logs of each stock price index in local currency and expressed as percentages. Descriptive statistics are shown in Table 2.1a. It can be seen that the US stock return has a standard deviation of 1.042, which is much lower than others, while stock returns of Taiwan, Korea, and Thailand have the highest volatility. Most of the series are highly skewed to the right, while the return series for the U.S. is skewed to the left. This shows that emerging markets have more positive extreme returns while the developed countries tend to have more negative ones. All of the series are highly leptokurtic and have fatter tails than normal distribution. The Jarque-Bera test indicates that none of the return series is normally distributed. Strong serial correlation is shown in significant Ljung-Box statistics. Table 2.1b lists the total market capitalization and total value traded at the end of 1996 for all these ten stock markets. Compared to the U.S. and Japan, other emerging economies have a much smaller stock market. Among those, Hong Kong, Taiwan, Malaysia, and Korea have relatively large stock markets and trade more actively. Furthermore, Figure 2.1 shows clustering of large returns and this phenomenon has been widely modeled by GARCH type of models in the past decade literature (see Bollerslev et al. (1992) for a detailed survey).

[Insert Table 2.1 about here]

[Insert Figure 2.1 about here]

Before turning to my methodology, Table 2.2a presents the simple pair-wise correlation matrix between the stock returns in the nine Asian countries. On July 2, 1997 Thailand officially announced the depreciation of its currency Baht. It would be appropriate to use this date to break the whole sample period into two sub-periods. Results in Table 2.2a show that the pair-wise correlations between these countries increase uniformly except some correlations involving Malaysia.[7] In order to test whether there is a significant increase in the correlation coefficients, correction for the heteroskedasticity problem suggested by F-R is used and then standard Z-test after Fisher Z-transformation is implemented.[8] One problem with this correction is that the source of contagion has to be identified in advance. [9] This study uses both Thailand (with breakpoint of July 2 1997) and Hong Kong (with breakpoint of October 17 1997) as the source of contagion and the results are shown in Table 2.2b. In both cases, the contagion effect is not as significant as that before the adjustment of the correlation coefficients, but still some evidence of correlation increase after the crisis can be seen. In order to further test whether the source of contagion matters, the order that these crisis countries were

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[7] Malaysia imposed strict capital control soon after the crisis, so it is understandable that its stock return behavior after the crisis might be different from before the crisis.

[8] Morrison (1983) suggests the test statistic for null hypothesis of no increase in correlation: $T = \frac{Z_0 - Z_1}{\mathrm{var}(Z_0 - Z_1)}$, where $Z_0 = \frac{1}{2}\ln(\frac{1+\rho_0}{1-\rho_0})$ and $Z_1 = \frac{1}{2}\ln(\frac{1+\rho_1}{1-\rho_1})$ are Fisher transformation of correlation coefficients before and after the crisis, and $\mathrm{var}(Z_0 - Z_1) = sqrt[1/(N_0 - 3) + 1/(N_1 - 3)]$ with $N_0 = 1956$ and $N_1 = 1493$ as the number of observations before and after the crisis. The test statistic is approximately normally distributed and is fairly robust to non-normality of correlation coefficients. Basu (2002) and Corsetti et al (2002) have employed this test.

[9] F-R argue that during the Asian crisis, the events in Asia became headline news in the world only after Hong Kong's market sharply declined in October 1997. Therefore they use Hong Kong as the only source of contagion and October 17, 1997 as the breakpoint of the whole sample period.

affected during the crisis is used to determine who is the source.[10] Then increases in 31 pair-wise correlation coefficients need to be tested.[11] The results of the test are shown in Table 2.2c, which are pretty similar to that in Table 2b. The results show that before correction, 29 out of 31 correlation coefficients reject the null hypothesis of no correlation increase while after correction, only 16 out of 31 reject the null hypothesis at 10% level.

[Insert Table 2.2 about here]

Preliminary analysis of the simple correlations here indicates that there is at least some contagion. But keep in mind that this simple correlation prevents the examination of the changes in the correlation matrix over time. Therefore multivariate GARCH models are employed to further pursue this issue.

2.4 Methodology: Multivariate GARCH-DCC model

This chapter employs a multivariate GARCH model with dynamic conditional correlation (DCC) that allows for time-varying conditional correlation, proposed by

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[10] The order of these countries is: Thailand (managed float of the baht on July 2, 1997), the Philippines (wider float of the peso on July 11, 1997), Malaysia (float of the ringitt on July 14, 1997), Indonesia (float of the rupiah on August 14, 1997), Singapore (large decline in stock market and currency market on August 28, 1997), Taiwan (large decline in stock and currency markets on October 17, 1997), Hong Kong (large decline in stock market on October 17, 1997), Korea (managed float of won on November 17, 1997), and Japan (stock market crash on December 19, 1997). Their respective breakpoints are also used, but the results are similar.

[11] There are (1+8)*8/2=36 pair-wise correlations with 5 correlation decreases in the case of Malaysia.

Engle (2002).[12] This GARCH-DCC model resolves the problem raised by F-R in that the conditional correlation estimated is also that of the standardized residuals. Since the standardized residuals account for the effect of the conditional variance, it alleviates the heteroskedasticity problem to a large extent. In addition, the model avoids the endogeneity problem by using the U.S. stock return as an exogenous global factor in the mean equation rather than using the source of contagion (e.g. stock return in Thailand) as an independent variable. Another advantage of this model is its parsimonious parameter setting. As you can see later, this chapter derives 45 pair-wise correlation coefficient series in a single estimation and it illustrates how the correlations between asset returns change over time, especially during the Asian crisis, and allows us to examine whether the correlation coefficients have increased during the Asian crisis and other events.

The model used in this chapter can be written as:

Mean Equations: $R_t = \gamma_0 + \gamma_1 R_{t-1} + \gamma_2 R_{t-1}^{US} + \varepsilon_t$ (2.2)

where $R_t = (R_{1,t}, R_{2,t}, \cdots, R_{10,t})'$, $\varepsilon_t = (\varepsilon_{1,t}, \varepsilon_{2,t}, \cdots, \varepsilon_{10,t})'$, $\varepsilon_t \mid I_{t-1} \sim N(0, H_t)$.

Since the US stock return has often been used as a global factor in the literature, I include 1-day lagged US stock return in addition to the AR(1) term in the mean equations of the other nine countries to account for the common shock.[13]

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[12] Another type of multivariate GARCH model with constant conditional correlation (CCC) is also used to estimate the correlation coefficients by splitting the sample using July 2, 1997 as breakpoint. The results are very similar to those in unconditional correlation analysis. In 34 pair-wise correlation increases, 30 are significant before the correction for heteroskedasticity and 20 are still significant after the correction.

[13] Neither exchange rate changes nor interest rate changes are included in the mean equations. During the crisis, exchange rates fluctuated a lot more than stock prices. Later in this study, it is shown that exchange rate changes can only explain a very small portion of stock market changes during the crisis. In addition, the interest rates data of these Asian countries do not have a consistent measurement and reflect government intervention via monetary policy, which makes it inappropriate to include interest rates changes in this high-frequency data study. As Baig and Goldfajn (1998) argue, overnight call rates were widely used as tools of monetary policy so that they reflect more about the policy stance rather than the market determined levels.

Variance Equations: $H_t = D_t V_t D_t$ (2.3)

$$\text{where } D_t = \begin{bmatrix} \sqrt{h_{11,t}} & 0 & 0 & 0 \\ 0 & \sqrt{h_{22,t}} & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & \sqrt{h_{10,10,t}} \end{bmatrix}_{(10\times 10)}, \; V_t = \begin{bmatrix} 1 & \rho_{12,t} & \cdots & \rho_{1,10,t} \\ \vdots & 1 & & \\ & & \ddots & \\ \rho_{10,1,t} & & & 1 \end{bmatrix}_{(10\times 10)}.$$

V_t is the conditional correlation matrix of the residuals or standardized residuals and $h_{11,t}$, $h_{22,t}$, …, $h_{10,10,t}$ are the variance equations for the ten stock returns. Expanding the variance-covariance matrices into individual equations will get:

$$h_{ii,t} = c_i + a_i h_{ii,t-1} + b_i \varepsilon^2_{i,t-1} \quad \text{i=1, 2, …, 10} \tag{2.4}$$

$$h_{ij,t} = \rho_{ij,t} \sqrt{h_{ii,t}} \sqrt{h_{jj,t}} \quad \text{i, j = 1, 2, …, 10 and i} \neq \text{j} \tag{2.5}$$

$$\rho_{ij,t} = q_{ij,t} / \sqrt{q_{ii,t} q_{jj,t}} \quad \text{i, j = 1, 2, …, 10 and i} \neq \text{j} \tag{2.6}$$

where the conditional covariance $q_{ij,t}$ between the standardized residuals $\eta_{i,t}$ and $\eta_{j,t}$ can be expressed in the following two ways. The first is the mean reverting approach, which is given by:

$$q_{ij,t} = \bar{\rho}_{ij}(1-\alpha-\beta) + \alpha q_{ij,t-1} + \beta \eta_{i,t-1} \eta_{j,t-1} \quad \text{i, j = 1, 2, …, 10 and i} \neq \text{j} \tag{2.7}$$

with $\eta_{i,t} = \varepsilon_{i,t} / \sqrt{h_{ii,t}}, \eta_{j,t} = \varepsilon_{j,t} / \sqrt{h_{jj,t}}$, and $\bar{\rho}_{ij}$ as the unconditional correlation between $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$. The average of $q_{ij,t}$ will be $\bar{\rho}_{ij}$ and the average variance will be 1. The above expression is mean reverting model when $\alpha + \beta < 1$. An alternative specification is the integrated model through exponential smoothing: $q_{ij,t} = (1-\lambda)\eta_{i,t-1}\eta_{j,t-1} + \lambda q_{ij,t-1}$.

This study focuses on the first specification because DCC model with mean-reverting process for conditional covariance of the standardized residual performs best among other methods (see the simulation results in Engle, 2002). Another advantage over other types of multivariate models, such as full vec model and BEKK model (Engle and Kroner, 1995) is that this model can easily be expanded to model N asset returns.

The estimation of the DCC model can be done by a two-step approach to maximizing the log likelihood function as:

$$L = \frac{1}{2}\sum_{t=1}^{T}(n\log(2\pi) + \log|H_t| + \varepsilon_t' H_t^{-1}\varepsilon_t) = \frac{1}{2}\sum_{t=1}^{T}(n\log(2\pi) + \log|D_t V_t D_t| + \varepsilon_t' D_t^{-1} V_t^{-1} D_t^{-1}\varepsilon_t)$$
$$= \frac{1}{2}\sum_{t=1}^{T}[(n\log(2\pi) + \log|D_t|^2 + \varepsilon_t' D_t^{-2}\varepsilon_t) + (-\eta_t'\eta_t + \log|V_t| + \eta_t' V_t^{-1}\eta_t)]$$

Since the first part of the likelihood function is not related to the correlation coefficient and it is simply the sum of individual GARCH likelihoods, it can be maximized in the first step over the parameters in D_t and then in the second step the correlation coefficients can be estimated given the parameters estimated in the first step.

2.5 Empirical Results

In order to show the power of this model, I will try to estimate as many correlation coefficients as possible in one single estimation, in this case, (1+9)*9/2=45 pair-wise correlation coefficients because there are 10 countries here.[14] Then this chapter focuses the analysis of correlation changes on two specific groups. The first group is the hardest-hit group, including Thailand, Indonesia, Malaysia, the Philippines and Korea. The objective is to see whether there is correlation increase during the crisis. The second

[14] The contemporary correlation coefficients between the US stock return and the other Asian stock returns may not have any practical meaning due to time zone difference. The Asian stock returns in day t is expected to be most affected by the US stock return in day t-1.

group includes Thailand, Indonesia, Malaysia, Korea and Japan to examine the different timing and magnitude of the contagion from the emerging markets to Japan.

Table 2.3 shows coefficients of the mean equations and variance equations. The AR (1) term in the mean equation is significantly positive for Thailand, Indonesia, Malaysia, Philippines and Singapore, while significantly negative for Hong Kong and Japan. However, it is not significant for Korea, Taiwan, and the US. The effect of the US stock return on the Asian stock returns is on average quite significant and consistent, ranging from 0.155 (Indonesia) to 0.474 (Hong Kong).[15] The variance equation for each country shows significant coefficients for past volatility and shocks. It can be seen that volatility is highly persistent in all countries.

[Insert Table 2.3 about here]

2.5.1 Empirical Results of Correlations for the Hardest-hit Group

Since there are 45 correlation coefficients derived from the GARCH-DCC model, this section mainly looks at the correlation coefficients between the stock returns of Thailand and those of the other four hardest-hit countries during the Asian crisis. The objective here is trying to see whether there is contagion effect from Thailand to Indonesia, Malaysia, the Philippines, and Korea. [16]

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[15] These results are consistent with the findings by Chiang, Jeon & Oh (1996).
[16] However, correlation coefficients can only illustrate contemporary relationship, therefore the direction of contagion effects here is only inferred from the sequence of the attack of the crisis countries.

2.5.1.1 Two Phases of the Crisis

Figure 2.2a shows the derived conditional correlation series between the stock returns of Thailand and those of Indonesia, Malaysia, Korea, and the Philippines for the whole period. Figure 2.2b magnifies the crisis period and Figure 2.2c shows all the pair-wise conditional correlation coefficients between the stock returns of these five hardest hit Asian countries from 1990 to 2003. The patterns are pretty similar to that in Figure 2.2a. These figures show that the pair-wise conditional correlations increased during the second half of 1997 and reached a high level during 1998. Although all the five countries in the graph were hit hard, the stock return of Thailand showed very low correlation (as low as –0.05) with stock return of the other four countries during the early stage of the crisis.[17] However, during the whole period of 1998, the correlation became significantly higher and persisted at the highest level ranging from 0.3 to 0.4 and began to decline at the end of 1998.

[Insert Figure 2.2 about here]

One possible explanation is that this is evidence of contagion effects in stock markets in the region during the early phase of the crisis and herding behavior in the latter phase.[18] Here contagion and herding behavior are distinguished in the sense that contagion describes the spread of shocks from one market to another with a significant increase in correlation between markets while herding describes the simultaneous

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[17] It should be noted that the low correlation during mid 1997 is not evidence against contagion effect.
[18] Several papers mention two different phases in the Asian crisis, e.g. Forbes (2000), Kallberg et al. (2002).

behavior of investors across different markets with high correlation coefficients in all markets.[19] When Thailand depreciated its currency, the investors still focused on Thailand, but not on other countries at the moment. Investors began to withdraw funds from Thailand and invest into other countries in the region. This resulted in the correlation decrease at the beginning of the crisis. As more and more countries fell out due to different transmission channels, investors began to panic and withdraw funds out of all the Asian economies.[20] During this process, the stock returns in these economies showed gradually increasing correlation as a sign of financial market contagion.

Given the prevailing increasing uncertainty in the markets, the cost of collecting credible information is relatively high during such period, and investors are likely to follow the other major investors to make their investing decisions. Any public news about one country may be interpreted as information regarding the entire region. That is why we see consistently high correlation during 1998, which is considered a result of herding behavior. Since I have daily data here, the division of the two phases has to be arbitrary to some extent. As observed, the second phase started when South Korea was hit and floated its currency won on November 17, 1997. Thereafter, news in any country would affect other countries, representing the most widespread panic.[21]

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[19] Herding is one phenomenon due to sudden shifts of investor sentiment or due to cross-market hedging.
[20] Kaminsky et al. (2000) indicate that bond and equity flows to Asia collapsed from their peak of 38 billion US dollars in 1996 to 9 billion dollars in 1998. Particularly Taiwan, Singapore, Hong Kong and Korea experienced respectively 12.91%, 11.75%, 6.91%, 6.49% average net selling (as percentage of the end of the preceding quarter holdings) in the two quarters following the outbreak of the crisis.
[21] Applying the threshold cointegration model to daily exchange rates, spot and forward, Jeon and Seo (2003) identified the exact breakpoint at November 18th 1997 for the Korean won, and August 15th 1997 for the Thailand baht.

2.5.1.2 Statistical Analysis

As shown in Figures 2.2, the pair-wise conditional correlation coefficients between stock returns of these Asian countries were seen to be persistently higher and more volatile in the second phase of the crisis. This leads to two important implications from the investor's point of view. First, a higher level of correlation implies that the benefit from market portfolio diversification becomes diminished. Second, a higher volatility of the correlation coefficients suggests that the stability of the correlation is less reliable, generating more uncertainty. For these reasons, tests are conducted to examine level shift and variance change on correlation coefficients.

Using three dummy variables for different sub-samples, the dynamic feature of the correlation changes can be investigated. The regression model is given by:

$$\rho_{ij,t} = \alpha_0 + \sum_{q=1}^{3} \alpha_q DM_{q,t} + \sum_{p=1}^{k} \alpha_{p+3} \rho_{ij,t-p} + \varepsilon_{ij,t} \qquad (2.8)$$

$i = Thailand;\ j = Indonesia, Malaysia, Philippines, Korea.$

where $\rho_{ij,t}$ is the pair-wise correlation coefficient between stock return of Thailand and those of the other four crisis countries, Indonesia, Malaysia, Korea, and the Philippines. $DM_{1,t}$ is the dummy variable for the first phase of the crisis period (7/2/1997-11/17/1997); $DM_{2,t}$ is the dummy variable for the second phase of the Asian crisis (11/18/1997-12/31/1998); $DM_{3,t}$ is the dummy variable for the post-crisis period (1/1/1999-3/21/2003). Since our pre-tests using ARCH-LM statistics find significant heteroskedasticity in all cases,[22] a GARCH(1,1) model with three dummy variables DM_1, DM_2, and DM_3 in variance equation is added to the system:

$$h_{ij,t} = \beta_0 + \beta_1 h_{ij,t-1} + \beta_2 \varepsilon_{ij,t}^2 + \sum_{q=1}^{3} \beta_{q+2} DM_{q,t} \tag{2.9}$$

The lag length of k is determined by the AIC criterion. As the model stands, if the dummy variable is significantly different from zero, for example, DM_1 is significant and positive in equation (2.8), that means during the first phase of the crisis, the correlation coefficient is on average higher than that in the pre-crisis period.

The model is estimated by using the maximum likelihood method. Table 2.4 reports the estimated results for the GARCH(1,1) model. The evidence shows that none of DM1 in the mean equations is statistically significant, indicating that the correlation during the early phase of the crisis is not different from that during the pre-crisis period. This may be attributable to a dramatic drop of the correlation coefficients in the first phase of the crisis period when contagion effect was not fully spread. However, all of DM_2 in the mean equations are statistically significant and positive, suggesting a notable increase in correlation during the second phase of the crisis compared to that of the pre-crisis period. This also signifies the existence of contagion process between the two sub-periods. Obviously, this contagious effect negates the benefit from holding a diversified international portfolio. After the crisis, the correlation coefficients decreased significantly in all cases except Korea. As expected, the investors became more rational in analyzing the individual market's fundamentals rather than herding after others. Thus, the correlation between market returns went down. The high correlation between stock returns of Thailand and Korea

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[22] LM tests are used for ARCH effect tests and results are available upon request.

after the crisis is consistent with the wake-up call hypothesis, where investors realize some similarity between the two markets' fundamentals after the crisis. Therefore, their trading strategy will be based on the related information in both markets. Meanwhile, the volatility of the correlation coefficients also increased due to the crisis in both the first phase and the second phase of the crisis. And this increase in volatility is permanent, shown from higher volatility in the post-crisis period. This evidence suggests that during the crisis, the correlation coefficient could vary greatly so that the estimates and statistical inference of the risk from risk models based on constant correlation coefficient can be very misleading.

[Insert Table 2.4 about here]

2.5.1.3 Comparison with Other Events and with Exchange Rates Behavior

The results in Figure 2.2 also allow us to examine other events during the 1990s. For example, during the Gulf war in 1990 and 1991, the correlations increased almost two times. During 1994 and 1995 the correlations coefficients also increased greatly, which might be due to the end of dual exchange rate system in China and the Mexico crisis. However, none of these events are as significant as the Asian crisis

In order to compare the behavior of the stock markets with that of the currency markets, I also show the pair-wise conditional correlation of the exchange rates between the crisis countries. Corresponding to Figure 2.2a and Figure 2.2b, Figure 2.3a and Figure 2.3b show the conditional correlation of the baht with the other four currencies. Compared with the stock markets, the currency markets had less activity and did not show a significant increase in correlation during 1997 and 1998. So the contagion effect in terms of correlation coefficients is not very strong, although the correlations did fluctuate more than before with similar patterns across countries. From this comparison, we can see that part of the fluctuations in the stock markets might come from the currency markets, but not all of them. The stock markets may process more information, such as the IMF programs, sovereign rating changes, and corporate news, while the currency markets had more government intervention. This again verifies that the stock markets are more important transmission channels than the currency markets.

[Insert Figure 2.3 about here]

2.5.2 Empirical Results of Correlations for the Group including Japan

The estimation results from the DCC model also help us to examine the possible existence of contagion effect between Japan and the crisis countries. In order to give a clear picture, I only include, in addition to Japan, four more important crisis countries, i.e. Thailand, Indonesia, Malaysia, and Korea. Figure 2.4a and Figure 2.4b show the correlation between the stock return of Japan and those of the other four during the whole sample and during the crisis. In Figure 2.4a, the Asian crisis is not as dramatic an event when compared to the effect of the 1990 Gulf War and the 2001 September 11 attack. The correlation coefficients generally remain low at around 0.15. However, during late 1997, only the stock returns of Malaysia and Japan had a high correlation of 0.20 for a short period (see Figure 2.4b). During early 1998, the correlation coefficients rose gradually. They reached a high of around 0.25 during September and October of 1998, when the U.S. hedge fund Long-Term Capital Management (LTCM) almost collapsed in September 1998. This is consistent with the findings in Arestis et al. (2003) that contagion from the Asian crisis countries to Japan took place in early 1998. While the contagion from the Asian crisis countries to Japan was quite slow and moderate, the effect of other events or factors might be more dramatic, which can be seen with high correlation coefficients of almost 0.4 during early 1990s and 2000s.

[Insert Figure 2.4 about here]

2.6 VAR Analysis

Since correlation analysis is studying the contemporary comovement of the stock returns, in this section I will examine the short-run dynamics of the stock returns during different sub-periods of the Asian crisis to see if transmission channels and source of contagion might change during the crisis. The fact that correlation only increased gradually from several months after July 2, 1997 inspires this study. The analysis in this section alleviates part of the problems with correlation analysis by using a more dynamic VAR system and a variance decomposition analysis.

2.6.1 Pre-tests for Data

Before I go on to the short-run analysis, whether these stock prices are cointegrated or not, i.e. whether they have long run relationships, should be examined.[23]

[23] ADF and PP tests show that all stock prices (in natural logs) are nonstationary at 1% significance level and all stock returns (first differences of log stock prices) are stationary. Results are available upon request.

If they do, then the traditional Vector Auto-regressive (VAR) analysis will be misspecified and error correction terms from the cointegration should be incorporated to represent the deviation from the long-run equilibrium. Since the hardest hit countries include Thailand, Malaysia, Indonesia and Korea,[24] and Hong Kong played an important role in the second phase of the crisis, the study in this section will only focus on these five. Too many variables will prevent us from observing the whole picture clearly.

As to the cointegration technique, I follow Sephton and Larsen (1991) iterated Johansen cointegration test[25] to examine the time-varying cointegrating relationships. The first Johansen test is based on the first 80 daily observations and then I add 20 observations each time to see how the test statistics change over time. The specification of the test I use here is that there is no deterministic trend in the data while there is an intercept but no trend in the cointegrating equation. I also tried other specifications of cointegration tests and the results are quite similar. The nonstandard critical values are taken from Osterwald-Lenum (1992), which differ slightly from those reported in Johansen and Juselius (1990). Figure 2.5a and 2.5b illustrate these test statistics over time. Generally there is no cointegrating relationship among the five countries in our sample.[26] There are a few times that one cointegrating relationship existed. However, these few exceptions are not robust results. Therefore for the rest of this section, I will assume no cointegrating relationship among the five stock price indices.

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[24] The Philippines is not included here when it was added to the VAR, its role was minimal.
[25] Sephton and Larsen (1991) argue that the tests of exchange market efficiency using cointegration are sensitive to model specification and sample period selection.
[26] Sheng and Tu (2000) find cointegration relationship among ASEAN and NIE countries respectively because of their sample period selection. They choose one year before the crisis as pre-crisis period and one year after the breakout of the crisis as post-crisis period. Since cointegration analysis is a long run analysis, one year sample period may be too short.

[Insert Figure 2.5 about here]

2.6.2 VAR and Variance Decomposition Analysis

A five-variable VAR system is established now to investigate how the shocks from one market were transmitted to other markets. The whole sample period is divided into four: the pre-crisis period (January 1, 1990 – July 1, 1997), the first-phase of the crisis period (July 2, 1997 – November 16, 1997), the second phase of the crisis period (November 17, 1997 – December 31, 1998), and the post-crisis period (January 1, 1999 - March 21, 2003). At most one or two lags should be included for efficient markets where stock prices adjust quickly to all relevant information. The lag exclusion Wald test shows that lag two is only significant for Malaysia at 5% significance level. So a 1-day lag is chosen for this VAR.

In a VAR system, variance decomposition analysis can separate the variation in an endogenous variable into the component shocks to the VAR. By dividing the sample into different sample periods, it can be seen which markets' shocks affect other markets most. Table 2.5a-d show the results of variance decomposition from the VAR models. Notice that the standard error increases significantly during the first phase and second phase of the crisis and goes back to its pre-crisis level for all countries but South Korea. I also want to look at the compositions of the variance during different periods. For example, Korea accounts for almost 98% of its own variance in the pre-crisis period after 10 days, for only about 86% during the first-phase of the crisis, for about 87% during the second-phase of the crisis, and for about 72% during the post-crisis period. During the first phase of the crisis, it seems that Malaysia and Hong Kong account for more variance in Korea.[27] During the second phase, however, Thailand took the lead, accounting for about 11% of Korea's variance. These findings are consistent with the analysis of Figure 2.2c. Although there was an increase in correlation between Thailand and Korea stock returns, the correlation only reached the peak later in 1998. However, the relationship between Malaysia and Korea stock returns reached its highest point much earlier, at the end of 1997. Korea's relationships with Indonesia and the Philippines seem to be relatively weak and increase relatively late during the crisis.

[Insert Table 2.5 about here]

The source of contagion might be different depending on the sample period and specific market. But generally speaking, Malaysia played a very important role in transmitting shocks during the first phase of the crisis. As seen in Table 2.1b, among those earliest-hit countries, Malaysia had the largest market capitalization and was the most actively traded.[28] Malaysia's influence diminished during the latter phase of the crisis due to its adoption of capital control. A surprising result is that Thailand was the most influential during the second phase of the crisis, even in other countries' cases. However, the role of Thailand in the second phase might be that either Thailand was the source of contagion or the ordering of the VAR is misspecified. I tried an alternative

[27] Malaysia and Korea both export electronics. On the other hand, Hong Kong and Korea are both NIEs and have relatively open financial markets.
[28] Kallberg et al. (2002) show that Malaysia suffered the most significant outflows in the second half of 1997.

ordering, putting Hong Kong in the first place.[29] The results are quite different with Hong Kong playing the most important role except in Korea case. Thailand was still more important in influencing Korea stock return. Since the results in variance decomposition are sensitive to the ordering of the variables, interpretation of these results should be cautious.

2.7 Summary and Conclusion

This chapter investigates the relationship between the stock returns of the crisis-struck countries, especially those hardest hit during the 1997 Asian financial crisis, using two different methodologies. The first emphasizes the estimation of contemporaneous correlation coefficients between stock returns, employing a multivariate GARCH model with dynamic conditional correlation. This model overcomes the heteroskedasticity and endogeneity problems in the traditional models and estimates the time-varying correlation series. Dynamics of the correlation series are then investigated, especially during the Asian crisis. It is found that after accounting for heteroskedasticity and endogeneity issues properly, there is evidence of contagion effects during the Asian crisis, in contrast with the "no contagion" conclusion in Forbes and Rigobon (2002). In addition, two phases of the crisis dynamics can be identified. In the first phase, there were significant increases in the correlation coefficients, while in the second phase the correlations remained high. One possible explanation is that the contagion effect took place early during the crisis and herding behavior dominated later on. The examination of Japan's case

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[29] Results for this ordering are not reported, but available upon request.

indicates that the contagion from the crisis countries to Japan is slower and smaller compared to the contagion among the Southeast Asian countries.

The second methodology complements the first one in that the VAR models investigate the dynamic short-run relationships among the stock returns. Using variance decomposition, it is found that Malaysia played an important role in transmitting shocks to other countries during the early stage of the crisis due to its more developed stock market, while Thailand and Hong Kong were affecting other countries the most during the second phase of the crisis.

The finding of at least some contagion during the crisis justifies the involvement of international institutions such as IMF to bail out countries that suffered from financial contagion. It also reduces the benefits of international diversification during the crisis periods and undermines the accuracy of risk management models.

Chapter 3. The Impact of Sovereign Rating Changes on Stock Market and Financial Contagion – The Case of Five Asian Countries

3.1 Introduction

The rapid spread of the 1997 Asian financial crisis within the region's five countries, namely Thailand, Indonesia, Malaysia, the Philippines, and Korea, has been partly attributed to the inappropriate measures of the international agencies, such as IMF, credit rating agencies, and large mutual fund managers. Before the occurrence of the crisis, none of these agencies had been able to foresee the impending event. For example, OECD accepted Korea as a member in October 1996 with the condition to open its capital account transactions, which later expedited the fall out of Korea. One of the largest credit rating agencies, DCR (Duff & Phelps Credit Rating Co.) upgraded the foreign currency rating of the Philippines from "BB-" to "BB+" on June 30th 1997, right before the crisis of Thailand. Another credit rating agency, Standard & Poor's, maintained high ratings ("A" band category) for these five Asian countries before the crisis. Some argue that the high ratings given by these international rating agencies before the crisis played an important role in inducing large flows of funds into the emerging markets in Asia. Even after the Thailand crisis began, the seriousness of the crisis had not been recognized soon enough. The IMF Report published on September 17th 1997 wrote: "There are reasons to believe that currency turbulence will eventually wane without greatly damaging the region."

However, as the crisis deepened, these agencies took some measures that are blamed by many to aggravate the crisis. IMF's bailout packages were blamed to adopt stringent monetary and fiscal policies, which might be effective for long-term management, but deepened the banking sector problems and crushed investors' confidence during the crisis. Even worse, the credit rating agencies largely (by several notches) downgraded the ratings of the crisis countries, which further reversed the expectations of the market participants and strengthened the financial turbulence during the last quarter of 1997. The largest downgrading of the foreign currency rating was that of Korea from a high of "AA-" before October 24th 1997 to junk grade "B+" at the end of 1997. The downgrade of long-term sovereign foreign currency rating to "B+" on December 22nd 1997 and the downgrades of best-known firms in Korea, such as Samsung Electronics Co., Hyundai Motor Co. and Daewoo Corp. on the next day were said to reflect the deepening pessimism and blow out the international effort to bolster confidence in Korea and might force pension funds and other investors to sell some of their holdings (December 23rd 1997, Wall Street Journal Eastern edition).

Some argue that these credit rating agencies, instead of giving warnings to investors before hand, are pro-cyclical, which means they upgrade the ratings in a booming market and downgrade the ratings in a slump market. They aggravated the crisis by giving no new information and at the same time misgiving the signals regarding the true positions of other neighboring countries, for which no such information was known at the moment and whose economic health are robust. Herding of the investors, thus, resulted after such downgrade announcements.

This argument is consistent with that in Calvo and Mendoza (2000). They argue that there is fixed cost of gathering and processing country-specific information and, under certain assumptions, the utility gain of paying this cost falls as the number of countries invested in increases. As the financial markets become more globalized, fund managers tend to speculate information in one country from information in another similar country. This information cost becomes extremely high during the crisis so that cross-market hedging and contagion occurs when fund managers sell assets in all markets in that region.

Due to these observations, this chapter is trying to answer the following questions: Did the rating changes during the crisis help the financial market recovery or worsen the situation? Did the rating changes in one country affect the financial markets in other crisis countries? Which rating changes were more contagious, the downgrades or the upgrades? This chapter combines the sovereign rating literature with the contagion literature and explores the role of sovereign rating changes in the context of stock market contagion during the Asian crisis.

Generally speaking, the stock markets respond to rating changes in their own countries. However, during the crisis, the responses to their own downgrades are not significant probably due to the expectations from the markets. Therefore, the downgrades during the crisis did not seem to worsen the financial situation. As to contagion effects, rating changes in one country affect the stock markets in other crisis countries. However, a large part of this contagion effect comes from the upgrades during the crisis and downgrades during the whole period. The rating upgrades in Korea boost the investor confidence in all the stock markets during the crisis and help the recovery of the financial markets. But the impact of downgrades on other markets during the crisis does not show much difference from that in other periods.

The organization of the chapter is as follows. Section 3.2 is a brief literature review on the impact of sovereign credit ratings on financial asset returns. Section 3.3

describes the data and Section 3.4 shows two methodologies used. Section 3.5 presents the empirical results and Section 3.6 summarizes the findings.

3.2 Literature Review

3.2.1 The Impact of Corporate Bond Rating Changes

There has been some event study literature on how corporate rating changes can affect the bond prices and stock prices of the firms (see Hand et al., 1992; Goh and Ederington, 1993). There are two key findings in this literature. In general, ratings upgrades have no impact on the bond and stock markets. For rating downgrades, there is a significant negative market response. However, there are also some other documented results. For example, the market may not respond to rating downgrades because many follow news of an increase in the firm's riskiness so that the downgrade has already been anticipated (see Goh and Ederington, 1993; McCarthy and Melicher, 1988). In addition, the impact of downgrades may spread to other stocks belonging to the same industry (see Akhigbe and Madura, 1997).

These results in corporate finance are relevant to this study because it was observed that the impact of sovereign rating downgrades spread to other neighboring countries and affected the stock markets in those countries. Like other credit ratings, sovereign ratings are assessments of the relative likelihood that a borrower will default on its obligations. They are important, however, because these ratings affect the ratings assigned to borrowers of the same nationality and determine the ability to borrow for both countries and companies. During the Asian crisis, the downgrades of the crisis countries' sovereign ratings greatly affected their companies' ability to borrow or rollover old debts in international capital markets. The main objective here is to examine the financial contagion through the sovereign credit rating changes during the crisis. Although the studies on corporate rating changes have been somewhat abundant and started in late 1980s, the study on sovereign rating changes started only after the Mexican crisis and especially after the Asian crisis. One reason might be the blame on the rating agencies during the crisis and another might be the lack of data because the sovereign rating assignments and changes have grown rapidly after 1990s.

3.2.2 The Impact of Sovereign Credit Rating Changes on Sovereign Bond Spreads

There have been several studies on the impact of sovereign credit rating changes on sovereign bond spreads. Cantor and Packer (1996) is the first to systematically analyze the determinants of the sovereign credit ratings and its impact on sovereign bond spreads. Using cross-sectional OLS regression, they find that six criteria play an important role in determining a country's rating. It is also shown that sovereign ratings effectively summarize information contained in macroeconomic indicators and may contain information not available in public sources. Their event study, using all announcements between 1987 and 1994, concludes that the announcement of sovereign rating changes affect bond yield significantly.

Larrain et al. (1997) employ a yearly panel Granger-causality test to see whether the two major rating agencies lead or lag market events. The results show that dollar bond spreads and a set of default determinants seem to explain somewhat better the level of sovereign ratings rather than vice versa. Their event study shows that for the full sample, the impact of rating announcements is only significant for emerging markets, but not for developed markets. After dividing the rating announcements into different categories, they only find highly significant short-run announcement effect when emerging market sovereign bonds are put on review with negative outlook. Reisen and von Maltzan (1999) extend the study to a longer period and more agencies. They use a monthly bivariate Granger-causality test and find two-way causality between rating changes and spreads changes. The event study shows a significant impact of imminent upgrades and actual downgrades from all three agencies on relative sovereign bond yield spreads.

Kraussl (2000) further adds a third variable to the bivariate VAR system - total foreign assets as a proxy for international liquidity. His objective of examining the impact of unexpected rating changes on the spreads and the international liquidity respectively leads to the use of decomposition technique in the VAR system. The case study of Korea shows that the unexpected rating downgrades had little impact on the liquidity, therefore implying that sovereign downgrades do not necessarily intensify the financial crises.

3.2.3 The Impact of Sovereign Credit Rating Changes on the Stock Returns

None of the above-mentioned papers focuses on the impact of sovereign rating changes on stock markets. Only recently two papers study this issue. Kaminsky and Schmukler (2002), using rating changes assigned by three major rating agencies from 16 emerging markets from 1990 to 2000, test the spillover effects across securities and countries, namely the impact of sovereign rating changes on stock returns and the contagion effect from one country's sovereign rating changes to another country's sovereign bond and stock markets. Their panel regression analysis shows that rating changes of bonds in one emerging market trigger changes in both yield spreads and stock returns in other emerging economies, confirming the contagion hypothesis. They also find that changes in credit ratings and outlooks have a stronger effect on both domestic markets and foreign markets during crises. Event study confirms that rating agencies are pro-cyclical and provide bad news in bad times and good news in good times. Brooks et al. (2003) only use event study to examine the impact of downgrades and upgrades on national stock market indices. They find that only downgrades convey information to the market. Among the four rating agencies examined, only downgrades by Standard & Poor's and Fitch result in significant market falls. No differences are found between the sensitivity to rating changes in emerging markets and non-emerging markets.

Since only Kaminsky and Schmukler (2002) examine the contagion effect, this study will basically follow their methodology. However, their paper does not examine the different impacts of downgrades and upgrades during the crisis. It does not distinguish the impacts of rating changes in different time periods. In addition, in their panel estimation, only the contemporaneous relationship between rating changes and stock return changes is examined and there is no country specific study.

This chapter studies the impact of sovereign credit rating changes on the national stock indices during the 1997 Asian crisis to fill in these gaps. The focus on the Asian crisis is due to the multiple significant downgrades during the crisis and a large amount of critiques on the downgrades afterwards. As we observed during the crisis, large downgrades of sovereign ratings of crisis countries seemed to aggravate the situation. One hypothesis here is that downgrades during the crisis worsened the stock markets in the crisis countries. The distinction between downgrades and upgrades is emphasized because in the corporate bond rating literature, generally downgrades have a significant impact while upgrades don't. Second, this chapter examines the different responses to rating changes during the crisis period versus during the tranquil period. It is expected that the downgrades during the crisis have a larger impact on the stock returns. Third, this study also improves the methodologies by using dynamic panel estimation and a more rigorous event study.

There are several reasons that sovereign credit rating changes will affect the national stock returns. One might be that sovereign rating downgrades limit the ability of all units within that country to borrow in the international capital markets and increase their borrowing costs. Since most of the companies that borrow abroad are large companies, which are included in the composite stock index, the high borrowing cost of those companies may be reflected in the companies' stock prices and therefore the national stock index. This is especially the case during the crisis when the rollover of old debts is critical for the survival of firms and banks and the stock prices drop dramatically when companies cannot borrow in favorable terms or lose the ability to borrow if the sovereign rating is below investment grade. Kaminsky and Schmukler (2002) also argue that governments may raise taxes on firms to neutralize the adverse budget effect of higher interest rates on government bonds triggered by the downgrades, thus affecting the stock market returns. As to the contagion effect during the crisis, the rating changes may act as a wake-up call, which hypothesizes that information in one country may trigger turbulence in other countries due to similarity between them. Another line of reasoning from Brooks et al. (2003) emphasizes that sovereign rating changes may reveal important information about country risk, which is critical for international portfolio management. A number of mutual funds offer country index portfolios. When such information about fundamentals is known, the fund managers will probably change the weightings of the index in their portfolios. This is known as the cross-market hedging channel.

3.3 Data

Unlike previous studies, this study only focuses on foreign currency rating changes for five Asian crisis countries from Standard & Poor's. There are several reasons: first, local currency ratings started much later than foreign currency ratings and almost all the changes of both ratings happened at the same time. Therefore including of both does not have any additional meaning. Second, during the crisis, other rating agencies, such as Moodys, Fitch IBCA, and Thomson, downgraded or upgraded the countries around the same time. Brooks et al. (2003) also find that Standard & Poor's have the greatest impact on market returns when announcing a rating downgrade. In order to minimize the repetitive information content, only Standard & Poor's rating changes are included here. Third, this study is going to focus only on five hardest hit crisis countries, namely Thailand, Indonesia, Malaysia, the Philippines and Korea. Other affected economies such as Hong Kong, Taiwan, Singapore and Japan are not included because their foreign currency sovereign ratings did not change much during the crisis.

Long-term foreign currency ratings represent a country's likelihood to default on foreign-currency denominated sovereign bonds. The rating scales of Standard & Poor's ratings are as follows. The highest band is the "A" band, which has seven notches: AAA, AA+, AA, AA-, A+, A, A-. The next band is the "B" level rating, which has nine notches:

BBB+, BBB, BBB-, BB+, BB, BB-, B+, B, B-. The lowest band has six notches: CCC+, CCC, CCC-, CC, SD (selective default) and D. Ratings above BB+ are considered investment grade while others are sub-investment grade. Cantor and Packer (1996) find that six factors are important criteria to determine the ratings: per capita income, GDP growth, inflation, external debt, level of economic development and default history. Outlook changes are also included here because they may have the same information content as rating changes. There are three outlook scales: positive, stable, and negative. The sovereign rating changes between January 1st 1990 and March 21st 2003 are obtained from Standard & Poor's Creditweek. Summary of the ratings are reported in Table 3.1. Reported also is the summary during the two sub-periods. The crisis period is defined as starting from July 2nd, 1997 when Thailand gave up defending its currency Baht and ending December 31st, 1998. The tranquil period is defined as periods other than the crisis period. The number of outlook changes is less than rating changes, largely due to the crisis period. There is an asymmetry between the two sub-periods, with most of the downgrades from the crisis period and a large portion of upgrades from tranquil period.

[Insert Table 3.1 about here]

In order to use these ratings, numerical values are attached to the ratings. Since there are a total of 22 notches where the lowest rating never shows up in the sample, the highest rating AAA is assigned 20 and the SD assigned 0. Negative outlook will add nothing to the value, while stable and positive outlooks add 1/3 and 2/3 to the rating values respectively. If there is an upgrade or a downgrade by one notch, then the rating is changed by +1 or -1. If there is an outlook change from positive to stable or from stable to negative, then the rating is changed by –1/3.

Daily stock market indices from Datastream International are obtained for the five countries during the period January 1st, 1990 to March 21st, 2003. They are Bangkok S.E.T. Index, Jakarta SE Composite Index, Kuala Lumpur SE Index, Philippines SE Composite Index, and Korea SE Composite Index for Thailand, Indonesia, Malaysia, the Philippines and Korea respectively. S&P 500 index is included as a global factor in affecting the stock markets in the world. MSCI Asia-Pacific Market Index excluding Japan is used in the event study as the market portfolio. The stock returns are calculated as log differences of stock indices and expressed in percentages.

To give you a basic idea of how the rating changes affect the stock indices, Figure 3.1 plots the pattern of stock indices and rating levels for these five countries. The rating changes are very consistent with the patterns in stock indices changes, although the former cannot fully explain the latter. Before the crisis, the rating rankings from the highest to the lowest are Korea, Malaysia, Thailand, Indonesia, and the Philippines. The ratings for Philippines did not seem to change that much during the crisis, while Korea suffered the most from the series of downgrades and the magnitude of that is the largest among the five.

[Insert Figure 3.1 about here]

3.4 Methodology

3.4.1 Panel Regressions [30]

In order to see whether the downgrades worsened the financial turbulence during the crisis, the following dynamic panel regression is established:

$$\Delta S_{i,t} = \beta_0 + \beta_1 \Delta S_{i,t-1} + \beta_2 \Delta S_{US,t-1} + \gamma_1 \Delta R^O_{i,t} + \gamma_2 \Delta R^O_{i,t-1} + \gamma_3 \Delta R^O_{i,t-2} + \gamma_4 \Delta R^O_{i,t-3} + \gamma_5 \Delta R^O_{i,t-4}$$
$$+ \gamma_6 \Delta R^O_{i,t+1} + \gamma_7 \Delta R^O_{i,t+2} + \gamma_8 \Delta R^O_{i,t+3} + \gamma_9 \Delta R^O_{i,t+4} \qquad (3.1)$$

where $\Delta S_{i,t}$, $\Delta S_{US,t}$, and $\Delta R^O_{i,t}$ represent the stock return in country *i*, the stock return in the U.S., and rating changes in its own country (O) respectively. One-day lag for the dependent variable is included to account for the autocorrelation of the series. One-day lag for the US return is employed to represent the global business cycle and considered exogenous in this case. Four-day lags and leads of own-country rating changes are included to show whether these ratings give investors information before hand or they are pro-cyclical.[31] The coefficients on own rating changes are expected to be positive because when there is an upgrade (or a downgrade), the stock return should be positive (or negative). If the ratings are pro-cyclical, it is expected that the lead variables of own rating changes have significant coefficients. If not, then the lag variables should have significant coefficients.

Contagion effects are examined using the following panel OLS estimation:

$$\Delta S_{i,t} = \beta_0 + \beta_1 \Delta S_{i,t-1} + \beta_2 \Delta S_{US,t-1} + \gamma_1 \Delta R^O_{i,t} + \gamma_2 \Delta R^O_{i,t-1} + \gamma_3 \Delta R^O_{i,t-2} + \gamma_4 \Delta R^O_{i,t-3} + \gamma_5 \Delta R^O_{i,t-4}$$

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[30] Note that the number of rating changes is rather small, especially during sub-periods and for country-specific studies. So the statistical power of these regressions may not be very strong.
[31] Macroeconomic fundamentals are not included because rating changes have summarized information in them (see Cantor and Packer, 1996).

$$+\gamma_6 \Delta R^O_{i,t+1} + \gamma_7 \Delta R^O_{i,t+2} + \gamma_8 \Delta R^O_{i,t+3} + \gamma_9 \Delta R^O_{i,t+4} + \theta_1 \Delta R^F_{i,t} + \theta_2 \Delta R^F_{i,t-1} + \theta_3 \Delta R^F_{i,t-2}$$

$$+\theta_4 \Delta R^F_{i,t-3} + \theta_5 \Delta R^F_{i,t-4} + \theta_6 \Delta R^F_{i,t+1} + \theta_7 \Delta R^F_{i,t+2} + \theta_8 \Delta R^F_{i,t+3} + \theta_9 \Delta R^F_{i,t+4} + \varepsilon_{i,t} \qquad (3.2)$$

where $\Delta R^F_{i,t}$ represents rating changes in other foreign countries (F). The coefficients on foreign rating changes measure the contagion effect and are expected to be significantly positive during the crisis.

Then the different roles of downgrades and upgrades are examined by estimating the following equation:[32]

$$\Delta S_{i,t} = \beta_0 + \beta_1 \Delta S_{i,t-1} + \beta_2 \Delta S_{US,t-1} + \gamma_1 \Delta R^{OU}_{i,t} + \gamma_2 \Delta R^{OU}_{i,t-1} + \gamma_3 \Delta R^{OU}_{i,t+1} + \gamma_4 \Delta R^{OD}_{i,t} + \gamma_5 \Delta R^{OD}_{i,t-1}$$

$$+\gamma_6 \Delta R^{OD}_{i,t+1} + \theta_1 \Delta R^{FU}_{i,t} + \theta_2 \Delta R^{FU}_{i,t-1} + \theta_3 \Delta R^{FU}_{i,t+1} + \theta_4 \Delta R^{FD}_{i,t} + \theta_5 \Delta R^{FD}_{i,t-1} + \theta_6 \Delta R^{FD}_{i,t+1} + \varepsilon_{i,t} \quad (3.3)$$

where $\Delta R^{OU}_{i,t}$, $\Delta R^{OD}_{i,t}$, $\Delta R^{FU}_{i,t}$ and $\Delta R^{FD}_{i,t}$ represent the upgrades in own country, downgrades in own country, upgrades in other countries, and downgrades in other countries respectively. If the downgrades aggravated the crisis, then one of the coefficients θ_4 , θ_5 , and θ_6 would be significantly positive when this equation is estimated during the crisis.

Each of these panel regressions is estimated for both the whole sample and two sub-periods to detect any differences between the crisis period and the tranquil period. Since these five countries might respond differently to the rating changes, time series analysis for each of them is also conducted using the same equations. For Thailand, Indonesia, Malaysia and the Philippines, equation (3) will not have $\Delta R^{OU}_{i,t}$ during the

[32] Results from equation (3.1) and (3.2) do not show interesting results for longer lags, therefore only 1-day lag and lead variables are used in equation (3.3).

crisis because the only two upgrades come from Korea. However, the number of rating changes is rather small in some of the cases.

3.4.2 Event Study Methodology

Since the panel regressions are limited by the small number of rating changes, standard event study is further employed to detect abnormal returns resulting from rating changes announcements. First, by using only own-country rating changes, the issue of pro-cyclical rating changes is addressed. Second, by using foreign-country rating changes, contagion effects during the crisis are studied. Third, focusing on the own-country and foreign-country downgrades during the crisis, the role of downgrades is examined. Event studies can also help to look into longer period impacts of rating changes.

The calculation and test of abnormal returns is pretty standard. The abnormal returns are calculated as daily raw returns adjusted by daily Morgan Stanley Asian-Pacific stock market composite index excluding Japan (MSAFXJL). As presented in the previous section, 67 sovereign rating or outlook changes for 5 countries are used as event observations. The event dates are identified in Standard & Poor's Credit Week. Setting the announcement dates as day 0, we examined the abnormal returns (ABR) and cumulative abnormal returns (CAR) from day -1 to day +1.[33]

[33] For various lengths of event windows, the announcement effect is most captured during these 3-day windows and the qualitative results of announcement effect didn't change.

3.5 Empirical Results

3.5.1 Results from Panel Regressions

The estimation results of equations (3.1) and (3.2) with panel data from all five countries are shown in Table 3.2. AR (1) terms are significant in all cases, indicating the existence of autocorrelation of stock returns. The coefficients on changes in the U.S. returns are all positive and significant, showing the strong effect from the U.S. Generally speaking, stock returns do respond to own country rating changes. Since the estimation from Equation (3.1) are very similar to that from Equation (3.2) and the latter contains more incremental variables, the analysis will focus on Equation (3.2). During the whole sample period, for rating upgrades (downgrades) of one notch, the stock return will increase (decrease) by 0.323% on the same day. The next day, the stock return will increase (decrease) by 0.399% with some mean-reverting behavior on the third and fourth day. Then, some mean-reverting behavior displays in the following days. With respect to the impact of pro-cyclical rating changes, there is no evidence of supporting the null.

[Insert Table 3.2 about here]

By examining the data, as we anticipated, contagion effects show up in both entire periods and crisis periods, while there are no significant coefficients in the tranquil period. Interesting enough, our evidence shows a profound contagion effect in the crisis period. Specifically, for one notch rating changes in other countries, the stock return in the studied country will change by 0.560% within a 24-hour period, which is smaller than impact of its own country's rating changes. In addition, stock market returns respond to foreign country rating changes (0.560%) more quickly than to own country rating changes (0.356%). This indicates the strong and swift contagion effects during the crisis, when investors are more sensitively accessing the news development in a cross country environment. The stock market returns respond to own raring changes slowly at 0.815% on a following day. Accordingly, the accumulated impact of own rating changes to stock market returns with a 48-hour period amounts to 1.171%, while that of foreign rating changes reaches 0.714%.

To further investigate different roles of upgrades and downgrades, equation (3.3) is estimated and the results are reported in Table 3.3. In order to avoid over-parameterizing and keep the parsimonious principle, we only include one-day lag and one-day lead for each rating variable. For the whole sample, the stock markets respond to both their own countries' upgrades and downgrades, while responding only to downgrades to foreign countries. The magnitude of downgrades is more profound than that of upgrades. This finding is consistent with corporate bond rating literature, indicating asymmetrical effects between downgrades and upgrades.

[Insert Table 3.3 about here]

When equation (3.3) is estimated for the two sub-periods, the story is different. During the crisis period, Korea responds to its own upgrade by lagging one day. The lead variable is negative and significant, indicating that the upgrade of Korea during the crisis is not pro-cyclical. The response to foreign country upgrades shows that all four other countries react strongly to Korea's upgrades. Stock returns increase by 1.114% with respect to one notch upgrade. This indicates that the market was quite inspired by the good news and the upgrades might contain some information that investors did not know.

Compared to results about upgrades, the downgrades do not seem to upset the markets during the crisis as expected. The markets are not affected by the news of downgrades in their own countries during the crisis. It seems that downgrades during the crisis did not worsen the turbulence as many blamed, compared to the tranquil period.[34] Possibly the market has interpreted other public news by the time of the sovereign rating downgrades. For example, before the downgrading of Thailand sovereign rating, there were already downgrading of many banking and finance companies. If this is the case, the downgrading of the sovereign should not be a surprise later. It is also possible that other agencies' downgrading is several days before the downgrading by Standard & Poor's. For example, Indonesia was downgraded by Fitch IBCA on January 8th 1998 while downgraded by both Moody's and Standard & Poor's on January 9th 1998. So the markets might have expected these two downgrades and already digested the information. The contagion effects from foreign country downgrades during the crisis are not different from that during the tranquil period. This indicates the existence of information asymmetry during the whole period and sovereign ratings contain information that foreign investors do not know.

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[34] As mentioned in the literature review, downgrades of the firm's bond ratings may not have a significant impact on its stock because the markets already expect the downgrade.

3.5.2 Results from Country-specific Studies

In country specific studies, the results for Thailand, Malaysia and Korea are shown in Tables 3.4 – 3.9 due to their uniqueness during the crisis period. In Thailand case, Table 3.4 shows that the stock market in Thailand responds more actively to its own rating changes and also foreign rating changes during the crisis, indicating strong contagion effects. However, this contagion effect might be different from the tranquil period due to the effect from upgrades during the crisis (see Table 3.5). This result is very similar to the panel estimation results. Thailand stock market seems to be affected by its own downgrades severely so that the downgrades in Thailand may have aggravated the financial turbulence.

[Insert Table 3.4 about here]

[Insert Table 3.5 about here]

In Malaysia case, the stock market responds to own rating changes relatively slowly, lagging two days (see Table 3.6). However, it responds to foreign country rating changes very quickly, especially during the crisis period. It is also shown that the lead variables are significant, indicating some signs of pro-cyclical behavior of rating agencies. Table 3.7 shows that Malaysia responds more strongly to other countries' downgrades during the crisis and this contagion effect lasts at least two days. Similar to Thailand, Malaysia also responds significantly to upgrades in Korea.

[Insert Table 3.6 about here]

[Insert Table 3.7 about here]

Korea was argued by many suffering the most from the contagion effect. During the crisis period, Korea responds to its own upgrade by lagging one day. The lead variable is negative and significant, indicating that the upgrade of Korea during the crisis is not pro-cyclical. The response to foreign country upgrades shows that all four other countries react strongly to Korea's upgrades. Surprisingly, no significant evidence to support that market responds to foreign countries' rating changes during the crisis (see Tables 8 and 9). Rather, Korea did show a significant response to its own downgrades, given that its own downgrades were dramatic and mostly announced in a short two-month period. Thus, similar to the case of Thailand, the downgrades worsened the crisis in Korea.

[Insert Table 3.8 about here]

[Insert Table 3.9 about here]

3.5.3 Results from Event Studies

In order to distinguish different impacts of upgrades and downgrades, the abnormal returns are calculated for upgrades and downgrades respectively. Similar to panel estimation, the whole sample period is divided into two sub-samples to see whether these upgrades and downgrades have different impacts during the crisis. The crisis period is from July 2, 1997 to December 31, 1998. The tranquil period is defined as all other dates.

To examine the contagion effect, the CAR of non-event stock market returns in this study is analyzed for the above event 67 events. Non-event observation is defined as the date when a specific country, out of 5 countries examined, does not have news, while there is some sovereign rating change news among the other 4 countries. Using this definition, 104 upgrade and 134 downgrade non-event observations are identified.

Table 3.10 reports the results of the event study. Panel A of the table shows the CARs of own upgrades and downgrades during the three sample periods. The CAR of 31 upgrades for the whole period is positive (0.54%), but these figures are statistically insignificant. There were 2 upgrades for Korea during the crisis; the CAR was positive and large (3.91%). However, the downgrades seem to have a significantly negative impact on the own national stock markets, especially during the crisis period, compared to the tranquil period (whole period,–2.29%; crisis period -2.92%; tranquil period, -1.17%).

The Panel B of the same table shows the results of analysis on contagion effects. The panel B shows that the CARs of upgrade non-event observations are positive (whole period, 0.30%; crisis period, 6.19%; tranquil period -0.63%) as expected, but statistically insignificant except the crisis period. On the other hand, the CARs of downgrade non-event observations are negative (whole period, -1.4%; crisis period, -2.15%; tranquil period, -0.21%), and statistically significant except the tranquil period. Putting together, the upgrades or downgrades in one country did impact the stock markets in other crisis countries. However, as we inspect the size of the coefficients, the evidence shows that the contagion effects of the upgrades were larger than those of the downgrades during the crisis period, subject to the small sample bias due to the insufficient number of observations. This is consistent with the findings in the panel estimation.

[Insert Table 3.10 about here]

3.6 Summary and Conclusion

This study contributes to the literature by examining the unique role of credit rating agencies during the Asian crisis. The contagion effects resulting from foreign countries' rating changes, either upgrades or downgrades, is also investigated. Findings from both panel regressions and country-specific studies are summarized as follows.

First, the credit agencies do not show strong pro-cyclical behavior during the crisis period. Second, the contagion effect from foreign countries' rating changes during the crisis is more prominent. However, this result may be essentially due to the strong effects of upgrades. Third, during the crisis, all five countries show strong responses to other countries' upgrades, indicating the importance of good news to market sentiment at bad times. Fourth, during the crisis, the downgrades did not have a significant impact on their own stock markets, implying the prices were internalized into market expectations. Sixth, evidence derived from the country specific studies shows that both Thailand and Korea suffered severely from their own downgrades during the crisis, indicating the fact that sovereign rating changes worsen the crisis development in these two countries.

In all the crisis-hit countries, the evidence consistently shows that the upgrades are contagious as well as the downgrades during the crisis. However, the comparison of the size of the coefficients indicates that the contagion effects of the upgrades may be larger than those of the downgrades. The event study, which applies the market-adjusted-return model to sovereign rating change announcements, confirms the major findings of the panel estimation on the contagion effects of the sovereign rating changes.

This chapter provides evidence of financial contagion through the channel of sovereign rating changes. Therefore, investors should be aware that the diversification benefit from investing in these Asian stock portfolios was significantly reduced during the Asian crisis due to the contagion effect. Investment in portfolios in the emerging economies should consider the possible risks that might incur when the emerging economies are more subject to crises of this kind.

Chapter 4. Regime-Switching in Currency and Stock Markets

4.1 Introduction

During the 1997 Asian crisis, financial shocks swept across countries and asset classes. The devaluation of the currencies in the crisis countries affected the rest of the economy, including the stock markets. There are two channels through which devaluation of a currency could affect these Asian economies.

The first channel is through the real economy. In order for devaluation of a currency to provide a boost to the real sector, other currencies in competing countries need to keep their values, otherwise the fallacy of composition works. However, the advantage from the devaluation of a currency might not be substantial if the import content of major items of exports is large in the crisis countries.[35] Moreover, a rational economic agent would expect a tighter monetary policy with a rise in domestic price as a result of the devaluation and therefore dampening of economic activity (Rakshit, 2002). The data of current account balance as a percentage of GDP in Table 4.1 Panel A supports this viewpoint. Current accounts in these economies were generally in deficit except Singapore and Taiwan in 1996. In 1997 and 1998 the current account balances were much higher in all of them except Taiwan and Japan.[36]

[Insert Table 4.1 about here]

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[35] Bartov and Bodnar (1994) argue that the impact of the exchange rate change on a firm depends on whether the firm has long or short economic position in the foreign currency. U.S. firms with a net long economic position (including exporters and firms with future cash inflows in foreign currency) will benefit (suffer) from a depreciation (appreciation) of the dollar, while U.S. firms with a net short economic position (including importers and firms with future cash outflows in foreign currency) will suffer (benefit) from a depreciation (appreciation) of the dollar.

[36] The low-frequency data available for macroeconomic indicators here might not illustrate the short-run dynamics in the currency market and stock market, but rather provide a picture of the long run impact.

The second channel is through the financial sector and could happen to emerging economies that adopt pegged or fixed exchange rate systems and experience a currency crisis. It is well known that banks and companies in the crisis countries had borrowed heavily from the international money market before the Asian crisis, in the form of short-term loans in foreign currency, to take advantage of the interest rate differential. Since most of the countries pegged their currencies to the U.S. dollar before the crisis, these borrowers did not expect foreign exchange risks and therefore did not hedge the risks. When the devaluation of a currency occurred during a currency crisis, banks and companies suffered from a great loss due to the currency and maturity mismatches in their balance sheets. When they could not roll over their short-term debts in the international capital markets, the stock markets experienced financial chaos.[37] As can be seen in Table 4.1 Panel B, the foreign liabilities in terms of national currency in 1997 increased dramatically after the devaluation or depreciation of the national currency. It indicates the seriousness of the exchange rate risk during a period of currency crisis.

However, both channels could be at work simultaneously. In this study, the objective is not to identify clearly what the transmission channel is, but mainly focus on the dominant effect at different times. While the financial contagion across countries is studied by many, the financial contagion across assets is not, especially when the

[37] Chang and Velasco (1998) set up a model that explains international illiquidity as a necessary and sufficient condition for financial crashes and/or balance-of-payments crises. As they define, international illiquidity is a maturity mismatch of a financial system's international assets and liabilities. The model assumes a bank that can accept demand deposits from domestic residents and borrow in the world market and can invest either in the world asset (liquid asset) or the long run asset to maximize their profits (zero profit in competitive markets). However, when domestic depositors and foreign creditors lose confidence in the banks as what happened in 1997, they will try to withdraw their money or not to roll over their loans in the short run, the banks have to liquidate some of their long term assets, which is costly.

currency markets experienced two different exchange rate regimes. Most of the countries changed from a pegged system to a managed floating system except Hong Kong and Malaysia during the Asian crisis. Hong Kong still kept its currency board system and Malaysia adopted a fixed exchange rate system after September 1998. This change of exchange rate regime leads to different perceptions about the exchange rate risks, and therefore results in a nonlinear relationship between stock returns and exchange rate changes.

The two channels through which currency market shocks can be transmitted to stock markets indicate that the relationship between stock returns and exchange rate fluctuations might not be linear. The dominant channel will determine the direction and magnitude of the relationship. This study examines the contagion from the currency markets to the stock markets in the Asian crisis countries and the nonlinear relationships between stock returns and exchange rate changes by using a Markov regime-switching model. It endogenously determines the regimes at any time and provides different estimates of exchange rate exposure of the stock markets at different times. The major finding is that the mean equation of the two-regime model with different variances seems to be a relatively good fit and shows intuitive results across countries. The exchange rate exposure is channeled mainly through the financial aspect during the “high volatility” regime, and through the real sector during the “low volatility” regime. This is consistent with the main hypothesis.

This chapter has two important policy implications for policy makers and those companies or banks that borrow from foreign countries in an emerging economy. When the policy makers choose to devalue a currency in a pegged exchange rate system under speculative attack, they should not only consider the real sector effect, but also take into account the cost of the financial channel effect. This cost might be extremely high for economies that borrow short-term loans heavily in foreign currency in a high growth environment, like the Asian economies did in the mid-1990s. For companies and banks that borrow heavily from the international capital markets under the pegged exchange rate system, they should realize different types of exchange rate exposure they may face when the exchange rate system changes. Appropriate hedging strategies should be adopted if the probability of an impending crisis is high.

The organization of this chapter is as follows. Section 4.2 introduces the literature on exchange rate risk and regime switching models and Section 4.3 presents the data and methodology used in this study. Section 4.4 shows the empirical results and Section 4.5 summarizes the findings.

4.2 Literature Review

4.2.1 Empirical Studies on Exchange Rate Risk in the Stock Markets

Most of the studies in the existing literature have focused on multi-factor asset pricing models and examined whether the exposure to exchange rate risk is priced in stock returns or not. Starting with Jorion (1990), many papers have measured the exchange rate exposure of U.S. firm and industry stock or portfolio returns (see, for example, Bartov and Bodnar, 1994). Further on, studies were extended to other countries, such as Germany, Japan, the United Kingdom, and Mexico, using national stock index or firm/industry level data (see, for example, Bailey and Chung, 1995; Dumas and Solnik, 1995; He and Ng, 1998).

However, the results are mixed. Jorion (1990) examines the exposure of U.S. industries to movements in the value of the dollar and finds that the exposure is quite different for different industries and the exposure is only significant for a few industries. Then in the APT model, it is shown that the exchange rate exposure is not priced in the stock returns of industry portfolios, possibly due to the assumption of constant pricing of exchange risk. Bartov and Bodnar (1994) find that lagged changes in the dollar are a significant variable in explaining current abnormal returns of their selected sample firms. Their reasons for an insignificant relationship between exchange rate changes and stock returns in the literature are the lagged effects and sample selection bias.

Using industry data from Japan and following Jorion (1990), Choi et al. (1998) find that the exchange risk is priced in the Japanese stock market. He and Ng (1998) take a different approach and examine the factors that could affect a Japanese multinational firm's foreign exchange exposure. They find that 25% of the sample have significant positive exposure, indicating that a depreciating yen has a favorable impact on Japanese MNCs whose exports form at least 10% of their sales. The exposure is determined by their level of export ratio and proxies for the firms' hedging policies.

The previously mentioned studies mostly concern developed economies with floating exchange rate systems and do not involve a change in exchange rate systems. This chapter is examining the different exchange rate exposure that the Asian economies faced when the exchange rate system changed dramatically during the Asian crisis.

4.2.2 Theoretical Development of Regime Switching Models

Hamilton (1989) first proposes the Markov switching ARIMA model, trying to model GDP growth rates in two possible states (expansion and contraction). The state variable is unobserved and modeled as a first-order Markov-process. This implies that the current regime only depends on the regime one period ago and the model defines the transition probabilities of moving from one state to the other. The regime switching models in the mean equations have been widely used since then.

However, the financial literature realized the heteroskedasticity of high-frequency financial series and used various GARCH models to show the properties of the time-varying volatility (see Bollerslev et al. (1992) for a detailed survey). Another strand of research has acknowledged the importance of large *sudden* shifts in volatility and their usefulness for estimating volatility persistence, and has used different techniques to deal with it. Lastrapes (1989), for example, applied the ARCH model to exchange rates and found that there is a significant reduction in the estimated volatility persistence if controls for monetary regime shifts are incorporated in the standard ARCH model.

While those monetary regime shifts were exogenously determined, Hamilton and Susmel (1994) employ a Markov-ARCH model (or SWARCH) for weekly U.S. stock returns and determine the structural changes endogenously. They illustrate that the traditional ARCH specifications have poor forecasting performance and spuriously high persistence in volatility and argue that those extremely large shocks such as 1987 stock market crash might have different consequences for subsequent volatility than do small shocks accounted for by the traditional ARCH models. They find that most of the persistence in stock price volatility is attributed to the persistence of low-, moderate-, and high-volatility regimes, which typically last for several years.

Later on, Gray (1996) extends the approach to GARCH models and solves the well-known path-dependency problem. At each time step, the conditional variance is obtained by aggregating the conditional variances from the two states in the previous period weighted by the regime probabilities. This aggregated conditional variance is then used to compute the conditional variance for the next period. This model assumes that the conditional variance at a certain time step is only dependent on the current regime, but not the entire past sequence of the regimes, and makes the GARCH / regime switching model tractable. To solve this path-dependency problem, Dueker (1997) uses a collapsing procedure that treats the conditional variance as a function of the most recent values of the state variable. This procedure greatly facilitates evaluation of the likelihood function at the cost of introducing a degree of approximation that does not appear to distort the calculated likelihood by much.

Since then, there have been many variants of regime-switching models in the financial literature. For example, Dewachter (2001) uses different transition probabilities for mean equation and variance equations. Klaassen (2002) uses somewhat different variance equation setup from Gray (1996) to facilitate the multi-period-ahead variance forecasting.

4.2.3 Empirical Applications of Regime Switching Models

There have been many applications of regime-switching models in the financial literature, especially to the exchange rate, stock price and commodity price dynamics.

Those include applications to the stock returns by Hamilton and Susmel (1994), Schaller and van Norden (1997), Dueker (1997) and Hess (2003); applications to the exchange rates by Fong (1998), Dewachter (2001) and Klaassen (2002); and applications to the interest rate by Gray (1996); applications to the oil price by Fong and See (2002).

Although all of these studies find regime-switching models a good fit for the targeted financial assets, none specifically looks at the relationship between the exchange rate changes and stock returns using regime-switching models. As I explained in the introduction, the different channels of exchange rate exposure during the crisis gives us the opportunity to study the financial contagion effect across assets. Holmes and Maghrebi (2002) is the only paper that studies the relationship between stock returns and exchange rate changes. However, they do not consider the possible GARCH effect in the stock returns and only model the volatility as a constant within each regime. Their focus on the discrete stochastic process does not allow for the GARCH effects that mainly look at the impact of relatively small shocks on return volatility. In addition, they focus more on the asymmetric effects of small depreciation vs. large depreciation.

This chapter contributes to the literature by looking at the exchange rate exposures through different channels at different regimes, therefore trying to answer the question why the exchange rate exposure differs across regimes. A regime-switching model is used to distinguish the two regimes endogenously. A relatively new technique developed by Gray (1996) is also used to model both the mean and variance equations of the stock returns as dependent on two regimes.

4.3 Data and Methodology

This study uses Datastream quotations for daily stock indices and exchange rates of nine Asian countries during the period of January 1 1990 to March 21 2003. Stock returns and exchange rate changes are obtained by taking the first differences of natural logs of the two variables. In Figure 4.1, the bilateral exchange rate in terms of local currency per U.S. dollar is shown. The similar pattern among Indonesia, Korea, Malaysia, the Philippines, and Thailand is striking. All the exchange rates were pegged to the U.S. dollar and fluctuating within a small band before the crisis, while after the sharp devaluation during the Asian crisis, the exchange rates were in a managed floating pattern except Malaysia, which adopted the fixed system. Figure 4.2 shows the exchange rate changes of these economies. Not surprisingly, the turmoil during the crisis brought extremely high volatility to the exchange rates. The descriptive statistics in Table 4.2 are consistent with what we've seen in Figure 4.1 and Figure 4.2. The exchange rate changes are highly skewed and leptokurtic, indicating the existence of extreme values and volatility clustering.

[Insert Figure 4.1 about here]

[Insert Figure 4.2 about here]

[Insert Table 4.2 about here]

First, in order to measure the exchange rate exposure of the national stock returns, single-regime linear model is estimated as the following:

$$R_t = \mu + \phi R_{t-1} + \omega R_{t-1}^{US} + \theta X_{t-1} + \varepsilon_t ,\ \varepsilon_t \sim N(0, h) \tag{4.1}$$

where R_t, R_t^{US} and X_t are the stock return in country i, stock return in the U.S. and exchange rate change in country i, respectively. The 1-day lagged US stock return R_{t-1}^{US} is used to account for global shocks. The 1-day lagged exchange rate change X_{t-1} is used to avoid the endogeneity problem.[38] The exchange rate exposure is measured by the coefficient θ. In the traditional framework, θ should be positive, indicating that a depreciation of the currency will benefit the economy in terms of trade balances and therefore boost up the stock market. It could also be insignificant because of high import content or rational expectation. However, as discussed before, the possible financial channel through the borrowers' balance sheets creates the possibility that θ might be negative.

Second, to distinguish different channels of currency market shocks, the stock return is modeled with the mean equation dependent on two regimes:

$$R_t = \mu_{S_t} + \phi_{S_t} R_{t-1} + \omega_{S_t} R_{t-1}^{US} + \theta_{S_t} X_{t-1} + \varepsilon_{S_t},\ \varepsilon_{S_t} \sim N(0,h) \tag{4.2}$$

The intercept and coefficients are all assumed to be dependent on the unobserved state S_t. The variance of the residual is assumed to be constant throughout the sample period. Switching probabilities of S_t is assumed to have a first-order Markov structure:

$Pr[S_t=1|S_{t-1}=1]=P11$

$Pr[S_t=2|S_{t-1}=1]=1-P11$

$Pr[S_t=1|S_{t-1}=2]=1-P22$

$Pr[S_t=2|S_{t-1}=2]=P22$

[38] Bartov and Bodnar (1994) find that lagged changes in dollar are significant in explaining abnormal returns while contemporary changes in dollar are not.

In order to estimate the parameters and the probabilities, the following conditional likelihood function needs to be maximized:[39]

$$L = \sum_{t=1}^{T} \log\left[p_{1t} \frac{1}{\sqrt{2\pi h}} \exp Z_1 + (1-p_{1t}) \frac{1}{\sqrt{2\pi h}} \exp Z_2 \right], \text{ where}$$

$$Z_1 = \frac{-(R_t - \mu_1 - \phi_1 R_{t-1} - \omega_1 R_{t-1}^{US} - \theta_1 X_{t-1})^2}{2h},\ Z_2 = \frac{-(R_t - \mu_2 - \phi_2 R_{t-1} - \omega_2 R_{t-1}^{US} - \theta_2 X_{t-1})^2}{2h},$$

$$p_{1t} = \Pr(S_t = 1 \mid \Phi_{t-1})$$

$$= (1 - P22)\left[\frac{g_{2t-1}(1-p_{1t-1})}{g_{1t-1}p_{1t-1} + g_{2t-1}(1-p_{1t-1})} \right] + P11\left[\frac{g_{1t-1}p_{1t-1}}{g_{1t-1}p_{1t-1} + g_{2t-1}(1-p_{1t-1})} \right].$$

To derive p_{1t}, we need to calculate the conditional density functions as follows:

$$g_{1t-1} = f(R_{t-1} \mid S_{t-1} = 1),\ g_{2t-1} = f(R_{t-1} \mid S_{t-1} = 2)$$

where $f(R_{t-1} \mid S_{t-1} = i) = f(R_{t-1} \mid S_{t-1} = i, \Phi_{t-2})$

$$= \frac{1}{\sqrt{2\pi h}} \exp\left\{ \frac{-(R_{t-1} - \mu_i - \phi_i R_{t-2} - \omega_i R_{t-2}^{US} - \theta X_{t-2})^2}{2h} \right\}.$$

In equation (4.2), θ could have different signs in different regimes. If the contagion from a currency market to a stock market is more through the real channel, then it could be positive, negative or insignificant; if more through the financial channel, then it could be only negative.

However, the constant-variance assumption in equation (4.2) is not realistic. It is well known that the high-frequency financial series has the volatility clustering property, which justifies different volatilities in two different regimes. Therefore, the following

[39] For details of estimation procedure, see Gray (1996).

equation assumes constant volatility within each regime but different volatility across regimes, and is estimated further to account for regime switching in volatility:

$$R_t = \mu_{S_t} + \phi_{S_t} R_{t-1} + \omega_{S_t} R_{t-1}^{US} + \theta_{S_t} X_{t-1} + \varepsilon_{S_t}, \ \varepsilon_{S_t} \sim N(0, h_{S_t}) \ . \tag{4.3}$$

To test the regime switches in the exchange rate exposure, another restricted version of equation (4.3) is also estimated and then likelihood ratio tests are conducted:

$$R_t = \mu_{S_t} + \phi_{S_t} R_{t-1} + \omega_{S_t} R_{t-1}^{US} + \theta X_{t-1} + \varepsilon_{S_t}, \ \varepsilon_{S_t} \sim N(0, h_{S_t}) . \tag{4.4}$$

Equation (4.4) assumes constant exchange rate exposure during the entire sample period, while still keeping other parameters in the equation dependent on two different regimes.

The likelihood ratio test is calculated as:

$$LR = -2(l_r - l_u) \sim \chi^2(n)$$

where l_u and l_r are the maximized values of the (Gaussian) log likelihood function of the unrestricted and restricted models, respectively. Under the null hypothesis that the additional parameters are not jointly significant, the LR statistic has an asymptotic distribution with degrees of freedom equal to the number of restrictions. Relative to equation (4.3), which is the unrestricted model here, both equation (4.2) and (4.4) are restricted models. Equation (4.2) imposes the restriction that the variance is constant across regimes while equation (4.3) imposes the restriction that the exchange rate exposure is constant. The number of restrictions is one.

Since the literature has shown tremendous evidence of GARCH effects in high frequency financial data, the discrete division of the regimes into two may not be sufficient. However, the traditional GARCH model will encounter the path-dependency problem because conditional variance at time t depends on the conditional variance at time *t-1*, which depends on the regime at time *t-1* and on the conditional variance at time *t-2*, and so on. Consequently, the conditional variance at time *t* depends on the entire sequence of regimes up to time *t* (Gray, 1996). Therefore, Gray (1996) suggests aggregation of conditional variance across regimes to get rid of the path-dependence problem. The conditional density of the residuals from the mean equation is assumed to be a mixture of distributions with time-varying mixing parameters, and the variance equation is modeled as:

$$h_{S_t,t} = \lambda_{S_t} + \alpha_{S_t}\varepsilon_{t-1}^2 + \beta_{S_t}h_{t-1} \tag{4.5}$$

$$h_{t-1} = p_{1t-1}[\tau_{1t-1}^2 + h_{1t-1}] + (1-p_{1t-1})[\tau_{2t-1}^2 + h_{2t-1}] - [p_{1t-1}\tau_{1t-1} + (1-p_{1t-1})\tau_{2t-1}]^2 \tag{4.6}$$

$$\varepsilon_{t-1} = R_{t-1} - [p_{1t-1}\tau_{1t-1} + (1-p_{1t-1})\tau_{2t-1}] \tag{4.7}$$

where p_{1t} is the conditional probability of staying in regime 1 at time t, $\tau_{1t-1} = \mu_1 + \phi_1 R_{t-2} + \omega_1 R_{t-2}^{US} + \theta_1 X_{t-2} + \varepsilon_{1t-1}$, and $\tau_{2t-1} = \mu_2 + \phi_2 R_{t-2} + \omega_2 R_{t-2}^{US} + \theta_2 X_{t-2} + \varepsilon_{2t-1}$.

The coefficients for the variance equations are expected to be significant, and $\alpha + \beta < 1$ so that the variance is stationary. The value of $\frac{\lambda}{1-\alpha-\beta}$ is the unconditional variance. One important assumption in this model is that the residual is assumed to be a normal distribution, so that at each time step the conditional variance can be aggregated at each step and be used to compute the conditional variances at the next time step.

4.4 Empirical Results on Mean Equations with Regime-Switching

According to the methodology section, various specifications of the Markov regime-switching models are estimated by maximizing the log likelihood function. For comparison purposes, the single regime model in equation (4.1) is estimated first (see Table 4.3). Mean reversion in stock returns (negative ϕ) does not appear to exist in any cases except for Japan. The U.S. stock return seems to have a consistently large impact on the Asian economies, corroborating its leading economic position in the global market. The foreign exchange exposure is shown to be only significantly positive in Thailand and Hong Kong's cases, insignificant in Indonesia's case, but significantly negative in all other six cases. This dominance in negative foreign exchange exposure contradicts the traditional viewpoint of transmission of currency shocks through the real channel and indicates the possibility of the financial channel.

[Insert Table 4.3 about here]

Therefore equation (4.2) is estimated with regime switches in all the parameters in the stock return equation, assuming same variance in different regimes. Regime 1 is defined as a "high return" regime and Regime 2 is defined as a "low return" regime. As can be seen from the estimation results in Table 4.4, the drift terms are generally in opposite signs. Mean reversion occurs in the "high return" regime in Thailand, Indonesia, Hong Kong, Taiwan, Singapore and Japan. Interestingly, the exchange rate exposure has negative signs in the "low return" regime in all cases except Indonesia, indicating the existence of the financial channel. In the other regime, it is either significantly positive (in Thailand's case), or significantly negative (in Taiwan's case), or insignificant (in all the other cases). The "high return" regime seems to be more persistent and lasts from 4 to

111 days. The "low return" regime is less persistent and only lasts about 1 to 2 days.[40] Diagnostic statistic $LB^2(15)$ is calculated to see if there is any time-varying volatility. The large significant Ljung-Box statistic for the squared standardized residuals strongly suggests the possible different volatility in the two regimes.

[Insert Table 4.4 about here]

Therefore, equation (4.3) is estimated with different variances in two regimes to at least account for discrete changes in variance across regimes. The results are shown in Table 4.5. After accounting for different variances, the drift terms mostly become insignificant and therefore, it is difficult to identify "high-return" and "low-return" regimes. Also, the mean reversion phenomenon disappears except in Japan's case. However, two regimes according to volatility can be identified as "high volatility" and "low volatility" regimes. The first row in each country's case is the "high volatility" regime and the second row is the "low volatility" regime. Compared with the "low volatility" regime, the volatility is at least one time higher up to almost three times higher in the "high volatility" regime. In the "high volatility" regime, five out of nine cases (Malaysia, the Philippines, Korea, Taiwan, and Singapore) turn out to have significant and negative foreign exchange exposure and two cases have insignificant and negative exposure (Indonesia and Japan). Malaysia adopted a fixed exchange rate system after September 1998, so the negative exchange rate exposure totally accounted for what

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[40] The persistence of each regime is calculated as $\frac{1}{1-P11}$ and $\frac{1}{1-P22}$ for regime 1 and 2 respectively.

happened during the Asian crisis, not after the crisis. Since Japan has a free floating exchange rate system, the significant and positive exchange rate exposure is not surprising. Hong Kong kept its currency board system throughout the sample and the fluctuation of the Hong Kong dollar was within a very small range. Therefore, the exchange rate exposure turns out not to be significant, indicating little exchange rate risk in Hong Kong. It is a little surprising that both the coefficients for exchange rate exposure turn out to be positive for Thailand, although not significant. However, in Thailand's case, it might be that the early devaluation of the Thai baht did give Thailand's companies competitive advantage in the export sector, therefore alleviating the financial channel effect.[41] In the "low volatility" regime, only Malaysia and Japan have significant and positive foreign exchange exposure and only the Philippines shows statistically significant and negative exposure. All the other 6 cases have insignificant exposure to exchange risk. This is consistent with the hypothesis that during the "high volatility" regime, the exchange rate exposure is channeled through the balance sheet effect while during the "low volatility" regime, the exchange rate exposure is channeled through the real sector effect. [42]

[Insert Table 4.5 about here]

There is persistence in both regimes with P11 and P22 both exceeding or close to 0.9. The average days in each regime is calculated and put into the brackets below each

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[41] From Table 4.1 it can also be seen that Thailand improved its current account condition in 1997 compared with 1996 and 1995 while the others had a much smaller improvement.

[42] A word of caution, though, is that the "high volatility" regime is not limited to the crisis period and might include other periods with local political turmoil, regional chaos, etc.

transition probability. For example, for Thailand, the “low volatility” regime on average lasts about 30 days while the “high volatility” regime on average lasts 13 days. It seems that the “low volatility” regime is more persistent than the “high volatility” regime. Some diagnostic statistics are reported. There is still significant autocorrelation in the squared standardized residuals, shown in $LB^2(15)$, but the statistics are much lower than those in Table 4.4. The log likelihood function value enables us to conduct a likelihood ratio test to see which equation is a better fit. In equation (4.2), the coefficient for exchange rate exposure is assumed to be equal, so it is considered the restricted model and equation (4.3) is considered the unrestricted model. The test statistics are reported in the second column of Table 4.6, showing a better fit of the unrestricted model – equation (4.3) with regime switching in the variance.

[Insert Table 4.6 about here]

To further test whether the regime switching in the foreign exchange exposure is warranted, equation (4.4) is estimated and the likelihood ratio test is conducted. The estimation results are reported in Table 4.7 and the likelihood ratio test statistics are shown in the third column of Table 4.6. As can be seen from Table 4.7, the estimation results are quite similar to Table 4.5. The regimes are divided between “high volatility” and “low volatility” and the persistence of each regime is almost the same as in Table 4.5. The $LB^2(15)$ statistics are slightly lower in all cases in Table 4.5 except the Philippines case. The likelihood ratio test shows that equation (4.3) is a better fit for Thailand, Malaysia, the Philippines, Korea, Singapore and Japan, while for the other three, equation (4.4) seems to be a better fit and more parsimonious. For Hong Kong, this result is not surprising, because it kept its currency board system during the crisis, therefore not exposing companies to greater exchange rate risks. Generally speaking, the two-regime models in mean equation with different variances are a better fit to describe the exchange rate risk at different regimes.

[Insert Table 4.7 about here]

After fitting the data with the two-regime model in mean equation with different variances, both the stock return and the conditional probability in the "high volatility" regime for each country are shown in Figure 4.3. The stock return volatility seems to correspond with the low vs. high regimes defined in the previous text. A common observation of the graphs for each stock market is that during the Asian crisis, the conditional probability of being in the "high volatility" regime was more frequent and stock markets moved more sharply across regimes. Although these graphs do not determine when the exchange rate regimes changed during the crisis, they do show that the stock markets are frequently changing between two regimes, with underlying economic fundamentals also changing.

[Insert Figure 4.3 about here]

As can be seen, Tables 4.5 & 4.7 still show significant autocorrelation in the squared standardized residuals, which justifies use of regime switching GARCH models to account for not only large shifts in volatility across regimes, but also the impact of small shocks on the conditional variance. Equations (4.5) to (4.7) plus the mean equation (4.3) are estimated simultaneously and the results are reported in the Table 4.8. The results seem to be very different from those in Table 4.4. Most of the significant exchange rate exposure effects disappear except for Malaysia and Taiwan. Thailand, on the other hand, turns out to have the wrong direction of signs on the exchange rate exposure, although it is still significant. According to the unconditional variance calculated from $\frac{\lambda}{1-\alpha-\beta}$, the regimes again are divided into "low volatility" and "high volatility" regimes, with the former on the first row and the latter on the second row for each country. However, it is surprising and even counter-intuitive that the "high volatility" regime is more persistent than the "low volatility" regime in all but the Indonesia and Malaysia cases. It is not surprising that the persistence of the shocks $(\alpha+\beta)$ is much lower than 1 after accounting for regime shifts in variance equations. This is consistent with the literature, which generally finds conditional variance in traditional GARCH models very close to 1 due to the inability to incorporate large shifts (Lastrapes, 1989).

[Insert Table 4.8 about here]

Diagnostic statistics show that after accounting for GARCH effects, the autocorrelation of the squared standardized effects is much smaller, although still significantly. The likelihood ratio tests of the regime-switching GARCH model vs. two-regime model in mean equation with different variances are shown in the fourth column of Table 4.7. The regime-switching GARCH model, in terms of diagnostic statistics, is a better fit than the two-regime model in mean equation with different variances. However, in terms of intuitive explanation, the latter does a better job. One reason might be that the assumption for the regime-switching GARCH model may not be realistic because the stock returns are well known to be non-normal and can be seen from the descriptive statistics in Table 4.2.

4.5 Summary and Conclusion

This chapter examines the exchange rate exposure of the national stock returns for the nine Asian economies during the sample period 1990 to 2003. Two possible transmission channels of currency shocks to stock markets are proposed. The first is through the real sector, with possible impacts of exchange rate changes on exports, imports and expected price. The second is through the financial sector, with impact on the liabilities on the balance sheets. The hypothesis here is that the financial channel is more dominant during the crisis period (or "high volatility" regime), while the real channel is more dominant during the tranquil period (or "low volatility" regime). None of the previous literature works has distinguished the two possible channels of contagion across assets; rather the literature has only considered the real channel.

This study applies the regime-switching models to this problem and finds strong supporting evidence for the financial channel during the crisis. Although the regime-switching GARCH model is a better fit, it does not provide an intuitive explanation of the coefficients. On the other hand, the two-regime model in mean equation with different variances seems to be a good fit and shows consistent results across countries. The "low volatility" and "high volatility" regimes are identified and the former is more persistent. The exchange rate exposure is channeled mainly through the financial aspect during the "high volatility" regime, while through the real sector effect during the "low volatility" regime. However, for Thailand, the real sector effect seems to be strong in both regimes, which makes sense due to the earliest depreciation of its currency during the crisis.

Improvements can be done to this study. First, if firm or industry level data is available for the crisis countries, it would constitute a better sample to look at the different exchange rate exposure at different times. Aggregate national stock indices may incorporate both export and import firms that can cancel out some of the real sector effects. Second, the methodology could be improved by modeling both stock returns and exchange rate changes as endogenous and dependent on two regimes. Exchange rate changes are endogenous variables, although in this case they are more controlled before the crisis. Third, improvement on the regime-switching GARCH models can be done by assuming two different state variables that depend on different regimes and this may provide more intuitive results in the future.

This chapter has important policy implications for policy makers and companies or banks that borrow from foreign countries in an emerging economy. The policy makers have to consider the high cost of financial channel effect when they decide to devalue the currency under a pegged exchange rate system. Companies and banks that borrow heavily from the international capital markets should be aware of the possible exchange rate risk that they may face once the exchange rate system collapse in a crisis and hedge appropriately.

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APPENDEX A: Tables

Table 2.1a Descriptive Statistics of Stock Returns (1/1/1990-3/21/2003)

	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	LB(16)
Hong Kong	0.034	0	17.247	-14.735	1.669	-0.021	12.632*	13333.32*	45.05*
Indonesia	-0.0004	0	13.128	-12.732	1.539	0.353*	14.228*	18188.95*	217.32*
Japan	-0.045	0	12.430	-7.234	1.502	0.261*	6.465*	1764.16*	28.41**
Korea	-0.013	0	10.024	-12.805	1.994	0.0001	6.712*	1979.95*	29.69**
Malaysia	0.001	0	18.773	-20.630	1.614	0.531*	28.915*	96670.48*	92.98*
Philippines	-0.002	0	16.178	-9.744	1.612	0.556*	11.868*	11477.66*	176.79*
Singapore	0.004	0	14.869	-9.672	1.339	0.234*	13.623*	16247.25*	117.67*
Taiwan	-0.022	0	12.836	-10.289	2.011	-0.030	6.124*	1402.69*	52.70*
Thailand	-0.026	0	11.350	-10.028	1.831	0.268*	7.613*	3099.78*	100.31*
U.S.	0.027	0.002	5.573	-7.113	1.042	-0.094**	6.882*	2170.24*	30.62**

Note: Observations for all series are 3449. *, ** denotes significance levels at 1% and 5% respectively. All variables are first differences of the natural log of stock indices. LB(16) refers to Ljung Box statistics with 16-day lag.

Table 2.1b Stock Market Characteristics (Year-End 1996)

	Total Market Capitalization	Total Value Traded
Hong Kong	449,381	166,419
Indonesia	91,016	32,142
Japan	3,088,850	1,251,998
Korea	138,817	177,266
Malaysia	307,179	173,568
Philippines	80,649	25,519
Singapore	150,215	42,739
Taiwan	273,608	470,193
Thailand	99,828	44,365
U.S.	8,484,433	7,121,487

Source: Forbes and Rigobon (2002). Unit: millions of US dollars.

Table 2.2a Simple correlation matrix of stock returns before and after the Crisis (July 2, 1997 as the break point)

	HK	IN	JP	KO	MA	PH	SG	TH	TW
Before the crisis:									
HK	1.000								
IN	0.172	1.000							
JP	0.251	0.060	1.000						
KO	0.077	0.015	0.047	1.000					
MA	0.434	0.208	0.237	0.108	1.000				
PH	0.200	0.188	0.082	0.053	0.226	1.000			
SG	0.504	0.222	0.319	0.133	0.640	0.266	1.000		
TH	0.310	0.158	0.148	0.141	0.358	0.211	0.391	1.000	
TW	0.141	0.043	0.143	0.094	0.142	0.139	0.174	0.141	1.000
After the crisis:									
	HK	IN	JP	KO	MA	PH	SG	TH	TW
HK	1.000								
IN	0.339	1.000							
JP	0.433	0.198	1.000						
KO	0.355	0.184	0.317	1.000					
MA	**0.336**	0.262	**0.211**	0.215	1.000				
PH	0.351	0.312	0.183	0.215	**0.213**	1.000			
SG	0.649	0.404	0.375	0.356	**0.385**	0.407	1.000		
TH	0.372	0.341	0.229	0.311	**0.336**	0.314	0.454	1.000	
TW	0.267	0.155	0.218	0.260	0.171	0.146	0.284	0.206	1.000

Note: HK, IN, JP, KO, PH, MA, SG, TH, and TW represent the stock returns of Hong Kong, Indonesia, Japan, Korea, the Philippines, Malaysia, Singapore, Thailand, and Taiwan, respectively. The bold are the cases for correlation decreases after the crisis.

Table 2.2b Test of Significant Increases in Correlation Coefficients (Thailand and Hong Kong as the Source of Contagion)

	Correlation before crisis	Correlation after crisis	Adj. Correlation after crisis	Z-Stat (Unadjusted)	Z-stat (Adjusted)
Thailand as the source:					
TH-HK	0.310	0.372	0.310	-2.041**	0.012
TH-IN	0.158	0.341	0.283	-5.695*	-3.817*
TH-JP	0.148	0.229	0.188	-2.443*	-1.189
TH-KO	0.141	0.311	0.257	-5.224*	-3.515*
TH-PH	0.211	0.314	0.260	-3.220*	-1.494***
TH-SG	0.391	0.454	0.383	-2.231**	0.290
TH-TW	0.141	0.206	0.169	-1.949**	-0.822
Hong Kong as the source:					
HK-TH	0.286	0.398	0.278	-3.702*	0.245
HK-PH	0.211	0.354	0.245	-4.524*	-1.035
HK-IN	0.203	0.334	0.230	-4.094*	-0.813
HK-SG	0.512	0.650	0.496	-6.114*	0.629
HK-TW	0.139	0.272	0.185	-4.032*	-1.371***
HK-JP	0.254	0.437	0.308	-6.069*	-1.719**
HK-KO	0.084	0.361	0.250	-8.553*	-4.990*

Note: Same as in Table 2.2a. Adjustment of the correlation is given in Equation (2.1). Z-tests are given in footnote (8). The null hypothesis is no increase in correlation. The 1%, 5%, and 10% critical value for a one-sided test of the null is –2.32, -1.64, and –1.28 respectively. *, **, *** indicate significance at the 1%, 5%, and 10% level respectively. Malaysia is not included due to a decrease in correlations after the crisis.

Table 2.2c Test of Significant Increases in Simple Correlation Coefficients

	Correlation before crisis	Correlation after crisis	Adj. Correlation after crisis	Z-Stat (Unadjusted)	Z-stat (Adjusted)
TH-HK	0.310	0.372	0.310	-2.041**	0.012
TH-IN	0.158	0.341	0.283	-5.695*	-3.817*
TH-JP	0.148	0.229	0.188	-2.443*	-1.189
TH-KO	0.141	0.311	0.257	-5.224*	-3.515*
TH-PH	0.211	0.314	0.260	-3.220*	-1.494***
TH-SG	0.391	0.454	0.383	-2.231**	0.290
TH-TW	0.141	0.206	0.169	-1.949**	-0.822
PH-HK	0.200	0.351	0.309	-4.763*	-3.402*
PH-IN	0.188	0.312	0.274	-3.852*	-2.644*
PH-JP	0.082	0.183	0.159	-2.992*	-2.286**
PH-KO	0.053	0.215	0.188	-4.807*	-3.977*
PH-SG	0.266	0.407	0.361	-4.636*	-3.053*
PH-TW	0.139	0.146	0.127	-0.208	0.355
MA-IN	0.208	0.262	0.164	-1.662*	1.316
MA-KO	0.108	0.215	0.134	-3.197*	-0.763
MA-TW	0.142	0.171	0.106	-0.864	1.066
IN-HK	0.172	0.339	0.172	-5.211*	-0.007
IN-JP	0.060	0.198	0.098	-4.087*	-1.098
IN-KO	0.015	0.184	0.090	-4.975*	-2.201**
IN-SG	0.222	0.404	0.210	-5.892*	0.380
IN-TW	0.043	0.155	0.076	-3.292*	-0.960
SG-HK	0.504	0.649	0.455	-6.364*	1.861
SG-JP	0.319	0.375	0.235	-1.852**	2.638
SG-KO	0.133	0.356	0.222	-6.934*	-2.683*
SG-TW	0.174	0.284	0.175	-3.379*	-0.017
TW-HK	0.141	0.267	0.309	-3.828*	-5.174*
TW-JP	0.143	0.218	0.254	-2.255**	-3.357*
TW-KO	0.094	0.260	0.302	-4.995*	-6.307*
HK-JP	0.251	0.433	0.300	-6.021*	-1.550***
HK-KO	0.077	0.355	0.241	-8.547*	-4.918*
KO-JP	0.047	0.317	0.092	-8.177*	-1.326***

Note: same as Table 2.2b. Pair-wise correlations between the stock returns in Malaysia and those in Thailand, the Philippines, Hong Kong, Japan and Singapore are not included because these correlation coefficients decreased after the crisis.

Table 2.3 Estimation results from GARCH-DCC model

	Return Equations			Variance Equations			
	γ_0	γ_1	γ_2	c	a	b	Persistence
TH	0.0448***	0.057*	0.228*	0.0615*	0.878*	0.109*	0.987
	(1.756)	(4.173)	(8.733)	(4.979)	(88.771)	(12.057)	
IN	0.0162	0.218*	0.155*	0.0137*	0.894*	0.117*	1.011
	(0.972)	(15.163)	(8.778)	(4.333)	(131.86)	(13.279)	
MA	0.0551*	0.129*	0.218*	0.0256*	0.892*	0.099*	0.991
	(3.224)	(9.856)	(14.090)	(5.817)	(117.59)	(13.084)	
KO	0.0145	0.001	0.324*	0.0454*	0.908*	0.082*	0.990
	(0.498)	(0.036)	(12.374)	(4.165)	(79.678)	(8.038)	
HK	0.0885*	-0.030*	0.474*	0.0363*	0.926*	0.058*	0.984
	(4.532)	(-2.568)	(23.344)	(6.018)	(160.23)	(13.712)	
JP	-0.0005	-0.046*	0.360*	0.0488*	0.899*	0.0798*	0.978
	(-0.023)	(-3.294)	(18.270)	(7.457)	(123.41)	(13.332)	
PH	0.0289	0.157*	0.282*	0.0582*	0.889*	0.0948*	0.983
	(1.165)	(10.703)	(11.773)	(5.359)	(97.069)	(11.975)	
SG	0.0457*	0.049*	0.330*	0.0316*	0.910*	0.071*	0.981
	(3.301)	(4.073)	(18.451)	(5.219)	(85.734)	(8.789)	
TW	0.0337	0.015	0.264*	0.0607*	0.917*	0.066*	0.983
	(1.124)	(1.183)	(9.090)	(5.601)	(105.89)	(9.545)	
US	0.0559*	0.015		0.0047*	0.943*	0.055*	0.998
	(3.568)	(0.979)		(3.434)	(151.25)	(8.624)	

Note: the same as Table 2.2. US represent the U.S. stock return. The estimates of the mean reverting process are α =0.006 (7.278), β =0.989 (480.292). The persistence level of the variance is calculated as the summation of the coefficients in the variance equations (a+b). The t-stats are in parentheses. *, **, *** denote 1%, 5%, and 10% significance level with critical values of 2.58, 1.96, and 1.65 respectively.

Return Equations: $R_t = \gamma_0 + \gamma_1 R_{t-1} + \gamma_2 R_{t-1}^{US} + \varepsilon_t$ (2.2)

where $R_t = (R_{1,t}, R_{2,t}, ..., R_{10,t})'$, $\varepsilon_t = (\varepsilon_{1,t}, \varepsilon_{2,t}, ..., \varepsilon_{10,t})'$, $\varepsilon_t \mid I_{t-1} \sim N(0, H_t)$.

Variance Equations: $h_{ii,t} = c_i + a_i h_{ii,t-1} + b_i \varepsilon_{i,t-1}^2$ i=1, 2, …, 10 (2.4)

Table 2.4 Tests of Correlation Increase between Stock Returns of Thailand and Those of the Other Four Crisis Countries – GARCH Model (1/1/1990-3/21/2003)

	Indonesia	Malaysia	Philippines	Korea
Mean Equation:				
Constant	0.0012***	0.0006***	0.0007***	0.0015***
	(3.563)	(3.376)	(3.506)	(5.789)
ρ_{t-1}	0.9947***	0.9965***	0.9958***	0.9906***
	(617.596)	(1644.042)	(987.179)	(629.207)
$DM_{1,t}$	0.0011	-6.39E-06	0.0009	-5.31E-05
	(0.988)	(-0.006)	(1.382)	(-0.094)
$DM_{2,t}$	0.0007*	0.0007***	0.0007*	0.0011***
	(1.650)	(2.750)	(1.801)	(2.794)
$DM_{3,t}$	-0.0002	0.0002	1.61E-05	0.0005***
	(-0.998)	(1.531)	(0.151)	(2.742)
Variance Equation:				
Constant	8.98E-06***	4.77E-06***	2.29E-06***	1.14E-06***
	(38.033)	(28.293)	(38.054)	(26.551)
ε_{t-1}^2	0.3637***	0.5425***	0.3176***	0.1440***
	(22.312)	(25.467)	(36.454)	(34.172)
h_{t-1}	0.3347***	0.3816***	0.7103***	0.8274***
	(21.654)	(25.760)	(144.773)	(256.083)
$DM_{1,t}$	2.77E-05***	2.96E-05***	3.48E-06**	9.04E-07*
	(6.773)	(7.825)	(2.270)	(1.699)
$DM_{2,t}$	1.87E-05***	4.18E-06***	1.21E-06***	3.11E-06***
	(12.632)	(8.092)	(2.827)	(8.489)
$DM_{3,t}$	2.00E-06***	2.88E-06**	-8.18E-07***	6.89E-07***
	(12.032)	(25.663)	(-12.967)	(10.321)
Q (16)	9.639	25.840*	24.245*	12.269
ARCH(4)	0.063	0.481	3.108	3.833

Note: These are estimates for Equation (2.8): $\rho_{ij,t} = \alpha_0 + \sum_{q=1}^{3} \alpha_q DM_{q,t} + \sum_{p=1}^{k} \alpha_{p+3} \rho_{ij,t-p} + \varepsilon_{ij,t}$ and Equation (2.9): $h_{ij,t} = \beta_0 + \beta_1 h_{ij,t-1} + \beta_2 \varepsilon_{ij,t}^2 + \sum_{q=1}^{3} \beta_{q+2} DM_{q,t}$. $\rho_{ij,t}$ is the correlation coefficient between the stock return of Thailand and those of the other four crisis countries, including Indonesia, Malaysia, the Philippines and Korea. $DM_{1,t}$, $DM_{2,t}$ and $DM_{3,t}$ is the dummy variable for the first phase (7/2/1997-11/17/1997), second phase (11/18/1997-12/31/1998) of the crisis period, and the post-crisis period (1/1/1999-3/21/2003) respectively. The lag length k is determined by AIC criterion. Q(16) is the Ljung-Box Q-statisitics up to 16 days, testing the serial correlation of the residuals. ARCH(4) is the ARCH LM test up to 4 days, testing the heteroskedasticity of the residuals. ***, ** and * represents significance level of 1%, 5% and 10% respectively. Numbers in parenthesis are Z-statistics.

Table 2.5a Variance Decomposition (Pre-crisis period: 1/1/1990-7/1/1997)

Period	Standard Error	TH	MA	IN	HK	KO
Variance Decomposition of TH:						
1	1.612	100.000	0.000	0.000	0.000	0.000
2	1.656	96.591	2.349	0.111	0.940	0.010
10	1.657	96.471	2.427	0.138	0.951	0.013
Variance Decomposition of MA:						
1	1.216	11.225	88.775	0.000	0.000	0.000
2	1.232	11.587	88.324	0.025	0.038	0.025
10	1.233	11.598	88.302	0.032	0.042	0.026
Variance Decomposition of IN:						
1	0.940	1.687	2.403	95.911	0.000	0.000
2	0.988	3.454	4.703	91.831	0.009	0.003
10	0.994	3.722	5.142	91.109	0.024	0.003
Variance Decomposition of HK:						
1	1.326	9.046	12.015	0.583	78.356	0.000
2	1.331	9.129	12.385	0.591	77.838	0.058
10	1.331	9.131	12.393	0.594	77.824	0.058
Variance Decomposition of KO:						
1	1.401	1.745	0.370	0.024	0.022	97.839
2	1.404	1.818	0.494	0.091	0.087	97.509
10	1.404	1.818	0.496	0.098	0.088	97.500

Table 2.5b Variance Decomposition (First Phase of the Crisis: 7/2/1997-11/16/1997)

Period	Standard Error	TH	MA	IN	HK	KO
Variance Decomposition of TH:						
1	2.585	100.000	0.000	0.000	0.000	0.000
2	2.775	91.520	3.807	1.098	0.183	3.393
10	2.806	90.078	4.310	1.564	0.205	3.843
Variance Decomposition of MA:						
1	2.490	3.170	96.830	0.000	0.000	0.000
2	2.594	3.726	92.465	2.254	1.551	0.004
10	2.616	3.887	91.174	3.276	1.652	0.010
Variance Decomposition of IN:						
1	2.502	9.246	17.344	73.410	0.000	0.000
2	2.627	10.192	15.961	72.269	1.494	0.084
10	2.631	10.339	15.915	72.142	1.503	0.101
Variance Decomposition of HK:						
1	3.486	0.760	20.494	13.475	65.271	0.000
2	3.577	0.803	19.801	13.970	64.381	1.045
10	3.581	0.803	19.835	14.052	64.259	1.051
Variance Decomposition of KO:						
1	2.269	2.835	6.539	0.007	3.880	86.740
2	2.338	3.145	6.516	0.797	3.655	85.887
	2.346	3.172	6.617	0.822	3.644	85.745

Table 2.5c Variance Decomposition (Second Phase of the Crisis: 11/17/1997-12/31/1998)

Period	Standard Error	TH	MA	IN	HK	KO
Variance Decomposition of TH:						
1	2.684	100.000	0.000	0.000	0.000	0.000
2	2.773	95.955	0.623	0.736	0.131	2.555
10	2.781	95.743	0.621	0.732	0.133	2.771
Variance Decomposition of MA:						
1	3.383	14.870	85.130	0.000	0.000	0.000
2	3.445	14.850	82.160	1.502	1.300	0.188
10	3.452	14.943	81.854	1.502	1.312	0.389
Variance Decomposition of IN:						
1	2.880	19.043	0.955	80.002	0.000	0.000
2	3.040	19.908	0.858	72.821	0.027	6.385
10	3.052	20.271	0.854	72.236	0.041	6.598
Variance Decomposition of HK:						
1	2.633	26.501	2.701	2.306	68.492	0.000
2	2.694	27.206	2.656	2.586	65.430	2.121
10	2.700	27.337	2.650	2.587	65.177	2.249
Variance Decomposition of KO:						
1	3.366	8.758	1.392	0.000	0.032	89.818
2	3.424	11.246	1.345	0.031	0.389	86.989
10	3.428	11.340	1.349	0.042	0.391	86.879

Table 2.5d Variance Decomposition (Post-Crisis Period: 1/1/1999-3/21/2003)

Period	Standard Error	TH	MA	IN	HK	KO
Variance Decomposition of TH:						
1	1.704	100.000	0.000	0.000	0.000	0.000
2	1.720	98.567	0.590	0.407	0.170	0.266
10	1.720	98.559	0.593	0.411	0.170	0.267
Variance Decomposition of MA:						
1	1.317	8.695	91.305	0.000	0.000	0.000
2	1.327	9.029	90.890	0.050	0.007	0.023
10	1.328	9.041	90.873	0.055	0.007	0.024
Variance Decomposition of IN:						
1	1.607	5.160	1.375	93.465	0.000	0.000
2	1.625	6.319	1.365	92.298	0.016	0.002
10	1.626	6.346	1.370	92.260	0.019	0.005
Variance Decomposition of HK:						
1	1.605	12.890	4.032	2.069	81.009	0.000
2	1.610	12.983	4.026	2.187	80.554	0.251
10	1.610	12.983	4.026	2.187	80.553	0.251
Variance Decomposition of KO:						
1	2.328	10.623	1.287	1.339	14.700	72.051
2	2.333	10.852	1.327	1.335	14.734	71.752
10	2.333	10.852	1.327	1.335	14.735	71.752

Note: the same as Table 2.2.

Table 3.1 Summary of Standard & Poor's Rating Activity (1/1/1990 to 3/21/2003)

	First appearance in sample	Number of rating changes	Number of outlook changes	Number of upgrades	Number of downgrades	Total number of changes
Panel A: Whole sample						
Thailand	1/1/1990	4	6	4	6	10
Indonesia	7/20/1992	15	3	5	13	18
Malaysia	1/1/1990	8	8	9	7	16
Philippines	7/2/1993	1	7	4	4	8
Korea	1/1/1990	10	5	9	6	15
Total		38	29	31	36	67
Panel B: Crisis period (7/2/1997-12/31/1998)						
Thailand		3	1	0	4	4
Indonesia		6	0	0	6	6
Malaysia		4	2	0	6	6
Philippines		1	1	0	2	2
Korea		5	2	2	5	7
Total		19	6	2	23	25
Panel C: Tranquil period (1/1/1990-7/1/1997 & 1/1/1999-3/21/2003)						
Thailand		1	5	4	2	6
Indonesia		9	3	5	7	12
Malaysia		4	6	9	1	10
Philippines		0	6	4	2	6
Korea		5	3	7	1	8
Total		19	23	29	13	42

Source: Standard & Poor's Creditweek 1990-2003.

Table 3.2 The Impact of Own Rating Changes and Foreign Rating Changes

Explanatory	Equation (3.1)			Equation (3.2)		
Variables	Whole Period	Crisis Period	Tranquil Period	Whole Period	Crisis Period	Tranquil Period
Constant	-0.019	-0.152**	-0.002	-0.021	-0.132*	-0.003
	(-1.402)	(-2.334)	(-0.146)	(-1.358)	(-1.952)	(-0.222)
AR (1)	0.102***	0.125***	0.087***	0.108***	0.125***	0.095***
	(6.011)	(2.987)	(6.554)	(5.687)	(2.962)	(6.590)
ΔR_{t-1}^{US}	0.348***	0.550***	0.304***	0.344***	0.535***	0.292***
	(20.881)	(9.516)	(19.911)	(19.564)	(9.265)	(18.266)
Change in ratings:						
Own country	0.346***	0.380	0.243*	0.323**	0.356	0.237*
	(2.641)	(1.266)	(1.822)	(2.491)	(1.232)	(1.801)
Lag1	0.413**	0.862**	0.110	0.399*	0.815**	0.111
	(1.965)	(2.133)	(1.110)	(1.930)	(2.093)	(1.113)
Lag2	-0.017	-0.239	-0.011	-0.012	-0.216	0.009
	(-0.077)	(-0.414)	(-0.095)	(-0.056)	(-0.375)	(0.082)
Lag3	-0.045	0.005	0.036	-0.037	0.022	0.042
	(-0.413)	(0.020)	(0.487)	(-0.335)	(0.079)	(0.577)
Lag4	-0.263	-0.730	-0.066	-0.249	-0.681	-0.054
	(-0.978)	(-1.027)	(-0.797)	(-0.924)	(-0.957)	(-0.650)
Lead1	0.080	-0.023	0.069	0.055	-0.064	0.048
	(0.334)	(-0.037)	(0.761)	(0.230)	(-0.101)	(0.535)
Lead2	0.071	0.176	-0.051	0.070	0.200	-0.048
	(0.454)	(0.507)	(-0.383)	(0.445)	(0.571)	(-0.357)
Lead3	0.159	0.659*	-0.035	0.160	0.662*	-0.042
	(0.991)	(1.843)	(-0.431)	(0.979)	(1.784)	(-0.516)
Lead4	-0.245	-	0.138*	-0.252	-0.970***	0.130*
	(-1.279)	(-3.113)	(1.901)	(-1.305)	(-2.978)	(1.810)
Foreign countries				0.277***	0.560***	0.080
				(2.859)	(3.182)	(0.683)
Lag1				0.151**	0.154	0.064
				(1.981)	(1.113)	(0.741)
Lag2				0.048	0.066	-0.009
				(0.640)	(0.414)	(-0.134)
Lag3				-0.164**	-0.474**	0.001
				(-2.068)	(-2.389)	(0.029)
Lag4				-0.068	-0.194	0.035
				(-0.889)	(-0.976)	(0.640)
Lead1				0.049	-0.132	0.074
				(0.750)	(-0.943)	(1.174)
Lead2				0.035	0.104	-0.012
				(0.527)	(0.615)	(-0.253)
Lead3				-0.018	-0.111	0.018
				(-0.211)	(-0.496)	(0.321)
Lead4				0.117	0.329	0.050
				(1.555)	(1.552)	(1.163)
Adjusted R-squared	0.058	0.084	0.052	0.063	0.092	0.054
Number of observations	15626	1960	13666	12635	1965	10675

Notes: the dependent variables are changes in stock returns for five Asian countries. Numbers in parentheses are t-statistics. ***, **, * represent significance level at 1%, 5%, 10% respectively.

Table 3.3 The Impact of Own/Foreign Country Upgrades/Downgrades

	Whole Period	Crisis Period	Tranquil Period
Constant	-0.009	-0.103	0.002
	(-0.691)	(-1.548)	(0.182)
AR (1)	0.100***	0.122***	0.087***
	(5.901)	(2.858)	(6.582)
ΔR_{t-1}^{US}	0.346***	0.542***	0.302***
	(21.062)	(9.284)	(20.663)
Change in ratings:			
Own country, upgrade	0.302**	-0.195	0.303***
	(2.201)	(-1.045)	(2.627)
Lag1	0.162	1.343***	0.027
	(0.945)	(3.996)	(0.238)
Lead1	-0.078	-1.633***	0.067
	(-0.340)	(-5.495)	(0.485)
Foreign country, upgrade	-0.022	1.114***	-0.192**
	(-0.230)	(6.205)	(-2.441)
Lag1	0.157	0.623***	0.098
	(1.629)	(2.791)	(0.954)
Lead1	0.050	-0.652*	0.129
	(0.519)	(-1.773)	(1.292)
Own country, downgrade	0.363	0.458	0.222
	((1.609)	(1.357)	(0.727)
Lag1	0.583*	0.747	0.266**
	(1.918)	(1.625)	(2.373)
Lead1	0.174	0.214	0.073
	(0.448)	(0.315)	(0.617)
Foreign country, downgrade	0.516***	0.459**	0.538**
	(3.516)	(2.390)	(2.254)
Lag1	0.084	0.101	-0.108
	(0.735)	(0.657)	(-0.670)
Lead1	0.064	-0.032	0.136
	(0.691)	(-0.212)	(1.454)
Adjusted R-squared	0.061	0.085	0.054
Number of observations	15656	1965	13696

Notes: same as in Table 3.2.

Table 3.4 The Impact of Own Rating and Foreign Rating Changes (Thailand)

Explanatory Variables	Equation (3.1) Whole Period	Crisis Period	Tranquil Period	Equation (3.2) Whole Period	Crisis Period	Tranquil Period
Constant	-0.030	-0.086	-0.024	-0.037	-0.095	-0.029
	(-0.995)	(-0.610)	(-0.802)	(-1.037)	(-0.627)	(-0.865)
AR (1)	0.117***	0.172**	0.100***	0.115***	0.167**	0.087***
	(4.267)	(2.294)	(3.701)	(3.741)	(2.281)	(3.125)
ΔR_{t-1}^{US}	0.346***	0.393***	0.330***	0.296***	0.390***	0.268***
	(10.117)	(3.422)	(9.459)	(8.453)	(3.345)	(7.710)
Change in ratings:						
Own country	1.352**	1.738***	-0.159	1.244***	1.512***	-0.617***
	(2.265)	(5.166)	(-0.064)	(3.424)	(3.571)	(-3.039)
Lag1	0.039	-0.224	0.443	-0.011	-0.360	0.678**
	(0.096)	(-0.459)	(0.799)	(-0.028)	(-0.839)	(2.147)
Lag2	0.306	0.944	-2.945	0.802	0.985	-1.524
	(0.288)	(0.998)	(-1.094)	(0.839)	(1.001)	(-0.861)
Lag3	-0.545	-0.751	-0.066	-0.622	-0.624	-0.300
	(-0.519)	(-0.547)	(-0.065)	(-0.570)	(-0.430)	(-1.135)
Lag4	0.368	0.407	0.303	0.585	0.583	1.141**
	(0.448)	(0.412)	(0.348)	(0.710)	(0.583)	(2.123)
Lead1	0.157	-0.727	3.447	-0.170	-0.729	2.394
	(0.192)	(-0.897)	(1.084)	(-0.228)	(-0.884)	(0.798)
Lead2	-0.155	-0.078	-0.626	0.096	0.026	0.505**
	(-0.531)	(-0.242)	(-0.649)	(0.363)	(0.089)	(2.263)
Lead3	0.796	0.540	1.490	0.715	0.629	0.922
	(1.529)	(1.346)	(0.725)	(1.483)	(1.276)	(0.462)
Lead4	1.138***	0.857*	1.934	0.987**	0.875*	1.032
	(2.842)	(1.863)	(1.266)	(2.342)	(1.901)	(0.830)
Foreign countries				0.284**	0.664***	0.083
				(2.035)	(2.652)	(0.574)
Lag1				0.196	0.098	0.178
				(1.432)	(0.390)	(1.134)
Lag2				-0.084	-0.153	-0.033
				(-1.044)	(-0.988)	(-0.371)
Lag3				-0.171	-0.362	-0.057
				(-0.912)	(-0.648)	(-0.493)
Lag4				-0.199	-0.407	-0.079
				(-1.108)	(-0.762)	(-0.816)
Lead1				0.020	0.002	-0.045
				(0.223)	(0.008)	(-0.520)
Lead2				-0.072	-0.034	-0.108
				(-0.601)	(-0.119)	(-0.894)
Lead3				-0.092	-0.052	-0.088
				(-0.642)	(-0.141)	(-0.589)
Lead4				-0.004	0.036	0.022
				(-0.039)	(0.118)	(0.256)
Adjusted R-squared	0.056	0.060	0.053	0.050	0.055	0.037
Number of observations	3441	392	3049	2527	393	2135

Notes: the dependent variables are changes in stock returns in Thailand. Numbers in parentheses are t-statistics. ***, **, * represent significance level at 1%, 5%, 10% respectively.

Table 3.5 The Impact of Own/Foreign Country Upgrades/Downgrades (Thailand)

	Whole Period	Crisis Period	Tranquil Period
Constant	-0.023	-0.078	-0.015
	(-0.748)	(-0.542)	(-0.503)
AR (1)	0.116***	0.167**	0.098***
	(4.223)	(2.248)	(3.633)
ΔR_{t-1}^{US}	0.345***	0.425***	0.329***
	(10.234)	(4.000)	(9.658)
Change in ratings:			
Own country, upgrade	-1.011**		-0.892**
	(-2.161)		(-1.975)
Lag1	0.680**		0.719***
	(2.550)		(2.701)
Lead1	2.127		2.053
	(0.803)		(0.772)
Foreign country, upgrade	0.017	1.467***	-0.115
	(0.100)	(5.641)	(-1.066)
Lag1	0.148	0.860*	0.054
	(0.779)	(1.837)	(0.278)
Lead1	-0.072	-1.098***	0.050
	(-0.494)	(-4.606)	(0.332)
Own country, downgrade	1.674**	1.544***	4.634
	(2.391)	(3.963)	(0.279)
Lag1	-0.256	-0.305	-1.459
	(-0.582)	(-0.693)	(-0.443)
Lead1	-0.281	-0.797	11.474
	(-0.345)	(-1.006)	(1.384)
Foreign country, downgrade	0.502***	0.483*	0.528***
	(3.252)	(1.915)	(3.429)
Lag1	0.210	0.002	0.332**
	(1.167)	(0.009)	(2.038)
Lead1	0.113	0.205	0.008
	(1.075)	(1.070)	(0.081)
Adjusted R-squared	0.058	0.073	0.055
Number of observations	3447	393	3055

Notes: the same as in Table 3.4. These are estimation results of Equation (3.3).

Table 3.6 The Impact of Own Rating and Foreign Rating Changes (Malaysia)

Explanatory Variables	Equation (3.1)			Equation (3.2)		
	Whole Period	**Crisis Period**	**Tranquil Period**	**Whole Period**	**Crisis Period**	**Tranquil Period**
Constant	-0.009	-0.245	0.017	-0.015	-0.157	0.015
	(-0.324)	(-1.359)	(0.748)	(-0.442)	(-0.881)	(0.516)
AR (1)	0.100	0.070	0.130***	0.093	0.063	0.126***
	(1.528)	(0.485)	(3.612)	(1.245)	(0.422)	(2.956)
ΔR_{t-1}^{US}	0.339***	0.662***	0.274***	0.327***	0.634***	0.250***
	(9.541)	(4.568)	(10.844)	(8.352)	(4.165)	(9.434)
<u>Change in ratings:</u>						
Own country	0.137	0.412	-1.030**	-0.086	0.163	-1.387**
	(0.255)	(0.507)	(-2.244)	-0.152	(0.203)	(-2.475)
Lag1	0.060	-0.277	0.588	(-0.026)	-0.242	0.582
	(0.111)	(-0.468)	(0.749)	-0.047	(-0.373)	(0.729)
Lag2	0.800***	0.593	1.098**	0.791***	0.650*	1.364**
	(3.212)	(1.502)	(2.205)	(3.053)	(1.651)	(2.153)
Lag3	-0.452	-0.635	-	-0.405	-0.522	-1.069***
	(-0.807)	(-0.742)	(-5.018)	(-0.673)	(-0.580)	(-5.315)
Lag4	0.379	0.429	-0.242	0.425	0.447	-0.243
	(0.587)	(0.508)	(-0.477)	(0.636)	(0.514)	(-0.460)
Lead1	-0.353	-0.611	0.474	-0.448	-1.025	0.854
	(-0.369)	(-0.599)	(0.742)	(-0.456)	(-1.084)	(1.095)
Lead2	0.843***	0.548	0.292	0.836***	0.878**	0.136
	(2.820)	(1.362)	(0.806)	(2.576)	(2.126)	(0.360)
Lead3	0.501	0.384	-0.244	0.628	0.296	0.263
	(0.914)	(0.501)	(-0.901)	(1.135)	(0.347)	(1.265)
Lead4	-1.969*	-2.021	-0.690*	-2.068*	-1.954	-0.693*
	(-1.823)	(-1.587)	(-1.810)	(-1.830)	(-1.396)	(-1.678)
Foreign countries				0.459**	0.890***	0.226
				(2.349)	(2.761)	(0.982)
Lag1				0.343**	0.552**	0.095
				(2.526)	(2.518)	(0.640)
Lag2				-0.021	0.042	-0.175
				(-0.128)	(0.127)	(-1.210)
Lag3				-0.129	-0.208	-0.075
				(-1.333)	(-0.813)	(-0.775)
Lag4				0.080	-0.027	0.139
				(0.862)	(-0.096)	(1.379)
Lead1				-0.094	-0.429*	-0.051
				(-0.883)	(-1.894)	(-0.694)
Lead2				0.049	0.290	-0.060
				(0.289)	(0.643)	(-0.927)
Lead3				-0.097	-0.006	-0.158***
				(-0.412)	(-0.008)	(-3.097)
Lead4				0.289**	0.616*	0.083
				(2.269)	(1.794)	(1.478)
Adjusted R-squared	0.063	0.061	0.067	0.063	0.065	0.057
Number of observations	3441	392	3049	2527	393	2135

Notes: the dependent variables are changes in stock returns in Malaysia. Numbers in parentheses are t-statistics. ***, **, * represent significance level at 1%, 5%, 10% respectively.

Table 3.7 The Impact of Own/Foreign Country Upgrades/Downgrades (Malaysia)

	Whole Period	**Crisis Period**	**Tranquil Period**
Constant	-0.001	-0.195	0.020
	(-0.033)	(-1.102)	(0.884)
AR (1)	0.089	0.045	0.129***
	(1.326)	(0.327)	(3.569)
ΔR_{t-1}^{US}	0.343***	0.678***	0.271***
	(9.484)	(4.762)	(11.811)
Change in ratings:			
Own country, upgrade	-1.117**		-0.992**
	(-2.068)		(-2.051)
Lag1	-0.072		-0.003
	(-0.139)		(-0.005)
Lead1	0.454		0.251
	(0.795)		(0.463)
Foreign country, upgrade	0.182	1.344***	-0.073
	(0.743)	(6.988)	(-0.595)
Lag1	0.281	0.687*	0.232
	(1.171)	(1.797)	(0.890)
Lead1	-0.028	-0.994***	0.074
	(-0.146)	(-12.433)	(0.447)
Own country, downgrade	0.406	0.131	-1.407**
	(0.742)	(0.162)	(-2.542)
Lag1	-0.016	-0.242	8.506***
	(-0.023)	(-0.408)	(29.097)
Lead1	-0.888	-0.908	11.021***
	(-0.817)	(-0.975)	(28.656)
Foreign country, downgrade	0.744***	0.747**	0.631*
	(3.228)	(2.151)	(1.888)
Lag1	0.306**	0.501**	-0.133
	(2.016)	(2.221)	(-0.880)
Lead1	-0.124	-0.264	-0.067
	(-0.981)	(-1.141)	(-1.213)
Adjusted R-squared	0.065	0.071	0.073
Number of observations	3447	393	3055

Notes: the same as in Table 3.6. These are estimation results of Equation (3.3).

Table 3.8 The Impact of Own Rating and Foreign Rating Changes (Korea)

Explanatory Variables	Equation (3.1) Whole Period	Equation (3.1) Crisis Period	Equation (3.1) Tranquil Period	Equation (3.2) Whole Period	Equation (3.2) Crisis Period	Equation (3.2) Tranquil Period
Constant	-0.027	-0.078	-0.016	-0.024	-0.075	-0.013
	(-0.811)	(-0.505)	(-0.517)	(-0.595)	(-0.431)	(-0.329)
AR (1)	0.019	0.062	-0.001	0.038	0.074	0.022
	(0.868)	(1.223)	(-0.035)	(1.547)	(1.401)	(0.830)
ΔR_{t-1}^{US}	0.452***	0.448***	0.456***	0.496***	0.436***	0.511***
	(11.003)	(3.432)	(10.886)	(10.687)	(3.290)	(10.648)
Change in ratings:						
Own country	0.382	0.455	-0.457	0.358	0.520	-0.429
	(0.960)	(0.988)	(-0.642)	(0.892)	(1.191)	(-0.615)
Lag1	1.625***	1.794***	-0.047	1.595***	1.727***	-0.145
	(5.289)	(6.054)	(-0.059)	(5.254)	(6.163)	(-0.178)
Lag2	0.154	0.007	0.626	0.099	-0.017	0.553
	(0.190)	(0.007)	(0.476)	(0.121)	(-0.018)	(0.420)
Lag3	0.390	0.312	1.011	0.383	0.335	0.957
	(1.232)	(0.881)	(1.479)	(1.141)	(0.828)	(1.418)
Lag4	-0.447	-0.408	-0.904	-0.478	-0.334	-1.049
	(-0.639)	(-0.507)	(-0.887)	(-0.684)	(-0.446)	(-1.021)
Lead1	0.373	0.403	-0.007	0.364	0.443	0.033
	(0.451)	(0.431)	(-0.005)	(0.437)	(0.459)	(0.023)
Lead2	-0.004	0.106	-1.003	-0.024	0.076	-0.997
	(-0.007)	(0.202)	(-0.704)	(-0.047)	(0.141)	(-0.714)
Lead3	0.249	0.292	0.155	0.261	0.198	0.142
	(0.514)	(0.512)	(0.250)	(0.529)	(0.328)	(0.225)
Lead4	-1.153***	-1.226***	0.186	-1.143***	-1.241***	0.122
	(-3.651)	(-3.673)	(0.424)	(-3.713)	(-3.906)	(0.272)
Foreign countries				0.104	0.493	0.033
				(0.345)	(1.321)	(0.093)
Lag1				0.057	0.268	0.016
				(0.277)	(0.451)	(0.078)
Lag2				-0.005	-0.346	0.092
				(-0.026)	(-0.633)	(0.463)
Lag3				-0.202	-1.355**	0.047
				(-1.033)	(-2.300)	(0.448)
Lag4				0.132	0.786*	0.033
				(0.940)	(1.838)	(0.267)
Lead1				0.065	-0.718	0.220*
				(0.322)	(-1.008)	(1.658)
Lead2				0.076	0.055	0.092
				(0.499)	(0.089)	(0.735)
Lead3				0.191	0.191	0.179
				(1.271)	(0.329)	(1.443)
Lead4				0.160	0.573	0.059
				(0.841)	(0.678)	(0.590)
Adjusted R-squared	0.069	0.070	0.064	0.085	0.075	0.085
Number of obs.	3441	392	3049	2527	393	2135

Notes: the dependent variables are changes in stock returns in Korea. Numbers in parentheses are t-statistics. ***, **, * represent significance level at 1%, 5%, 10% respectively.

Table 3.9 The Impact of Own/Foreign Country Upgrades/Downgrades (Korea)

	Whole Period	Crisis Period	Tranquil Period
Constant	-0.010	0.001	-0.014
	(-0.303)	(0.007)	(-0.433)
AR (1)	0.021	0.076	-0.001
	(0.964)	(1.360)	(-0.025)
ΔR_{t-1}^{US}	0.446***	0.414***	0.453***
	(11.440)	(3.269)	(11.756)
<u>Change in ratings:</u>			
Own country, upgrade	-0.295	-0.353	0.025
	(-1.179)	(-1.569)	(0.034)
Lag1	0.865**	1.373***	-0.141
	(2.178)	(3.612)	(-0.165)
Lead1	-1.052	-1.662***	0.204
	(-1.335)	(-4.943)	(0.134)
Foreign country, upgrade	-0.330**		-0.399***
	(-1.971)		(-2.944)
Lag1	0.177		0.178
	(0.909)		(0.899)
Lead1	0.235		0.249
	(1.065)		(0.964)
Own country, downgrade	0.666	0.789	-4.377***
	(1.245)	(1.425)	(-49.239)
Lag1	1.894***	1.842***	0.438***
	(6.266)	(6.285)	(4.287)
Lead1	1.003	1.101	-2.692***
	(1.093)	(1.117)	(-44.642)
Foreign country, downgrade	0.574	0.521	0.646
	(1.166)	(1.467)	(0.823)
Lag1	-0.186	0.310	-0.534**
	(-0.551)	(0.553)	(-1.968)
Lead1	-0.076	-0.769	0.350*
	(-0.194)	(-1.113)	(1.656)
Adjusted R-squared	0.071	0.077	0.068
Number of observations	3447	393	3055

Notes: the same as in Table 3.8. These are estimation results of Equation (3.3).

Table 3.10 Abnormal Returns around Sovereign Rating Changes

	Rating upgrades			Rating downgrades		
	CAR	N	t-stat	CAR	N	t-stat
Panel A: Own rating changes						
Whole period	0.0054	31	0.85	-0.0229**	36	-2.61
Crisis period	0.0391	2	0.53	-0.0292**	23	-2.34
Tranquil period	0.0031	29	0.57	-0.0117	13	-1.17
Panel B: Foreign rating changes						
Whole period	0.0030	104	0.87	-0.0140***	134	-3.51
Crisis period	0.0619***	8	3.70	-0.0215***	84	-3.53
Tranquil period	-0.0063	96	0.67	-0.0021	52	-0.70

Note: CAR is the cumulative abnormal return for the event window of (-1, 1), estimated using the mean-adjusted model. Market return is the return of the MSCI Asia-Pacific Market Index excluding Japan. N is the number of events. The whole period is from January 1, 1990, to March 21, 2003. The crisis period is from July 2, 1997, to December 31, 1998. The tranquil period is all other dates except the crisis period. *** and ** represent the significance at the 1% and 5% levels, respectively.

Table 4.1 Current Account Balance and Foreign Liabilities in the Crisis Countries

	1995	1996	1997	1998	1999	2000	2001
A. Current Account Balance (% of GDP):							
Thailand	-8.1	-8.1	-2.0	12.7	10.1	7.6	5.4
Indonesia	-3.2	-3.4	-2.3	4.3	4.1	5.2	n.a.
Malaysia	-9.7	-4.4	-5.9	13.2	15.9	9.3	n.a.
Philippines	-2.7	-4.8	-5.3	2.4	10.4	11.3	6.3
Korea	-1.7	-4.4	-1.7	12.7	6.0	2.7	2.0
Hong Kong	n.a.	n.a.	n.a.	2.4	7.3	5.5	7.4
Taiwan	1.8	4.0	2.3	3.1	2.8	3.0	6.6
Singapore	17.9	14.1	19.0	24.7	26.3	23.5	n.a.
Japan	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B. Foreign Liabilities in Deposit Money Banks (Billions of National Currency):							
Thailand	1164	1249	1904	1066	718	566	462
Indonesia	26952	29744	70434	97842	100375	92674	68406
Malaysia	16	28	48	35	28	26	23
Philippines	168	378	616	498	483	515	449
Korea	24361	36454	47418	35464	31348	31366	27964
Hong Kong	4797	4486	4627	3465	2890	2488	2061
Taiwan	n.a.	483	489	479	462	458	540
Singapore	66	77	105	84	89	102	115
Thailand	1164	1249	1904	1066	718	566	462

Source: International Financial Statistics from IMF. “n.a.” means “not available”. Data for Taiwan is from central bank of Taiwan.

Table 4.2 Descriptive Statistics of Stock Returns and Exchange Rate Changes

	Mean	Std. Dev.	Skewness	Kurtosis	Jarque Bera
Stock Return:					
Thailand	-0.026	1.831	0.268***	4.622***	3111.013***
Indonesia	-0.001	1.539	0.353***	11.246***	18247.266***
Malaysia	0.001	1.614	0.531***	25.954***	96963.928***
Philippines	-0.002	1.612	0.556***	8.882***	11515.081***
Korea	-0.013	1.994	0.0002	3.719***	1987.565***
Hong Kong	0.034	1.669	-0.021	9.648***	13376.878***
Taiwan	-0.021	2.011	-0.030	3.130***	1408.332***
Singapore	0.004	1.339	0.234***	10.640***	16299.706***
Japan	-0.046	1.502	0.261***	3.471***	1770.943***
Exchange Rate Changes:					
Thailand	0.015	0.685	4.097***	130.285***	2448991.539***
Indonesia	0.047	1.941	2.693***	83.078***	996041.159***
Malaysia	0.010	0.556	0.082*	63.748***	583998.268***
Philippines	0.027	0.708	1.504***	58.809***	498311.227***
Korea	0.018	0.894	-1.408***	129.789***	2421928.284***
Hong Kong	-2.27E-05	0.035	-0.701***	651.555***	544802.851***
Taiwan	0.008	0.319	1.813***	49.074***	347977.469***
Singapore	-0.002	0.367	-0.617***	16.795***	40755.535***
Japan	-0.005	0.726	-0.824***	8.001***	9590.757***

Notes: The sample period is from January 1, 1990 to March 21, 2003. Stock returns are 100 times first differences of natural log of stock indices while exchange rate changes are 100 times first differences of natural log of exchange rates. ***, **, * indicates significance levels of 1%, 5% and 10% respectively. Jarque-Bera statistics test for normality.

Table 4.3 Single Regime Model

	μ	ϕ	ω	θ	$LB^2(15)$
Thailand	-0.034	0.120***	0.350***	0.090**	1079.46***
Indonesia	-0.007	0.194***	0.258***	0.003	725.87***
Malaysia	-0.005	0.066***	0.342***	-0.293***	1357.34***
Philippines	-0.006	0.171***	0.332***	-0.172***	228.66***
Korea	-0.023	0.014	0.457***	-0.132***	984.92***
Hong Kong	0.019	-0.015	0.593***	1.305*	1325.92***
Taiwan	-0.028	0.029*	0.362***	-0.236**	2718.17***
Singapore	-0.009	0.102***	0.428***	-0.241***	650.20***
Japan	-0.059**	-0.058***	0.415***	-0.011	483.36***

Note: Estimation results for Equation (4.1): $R_t = \mu + \phi R_{t-1} + \omega R_{t-1}^{US} + \theta X_{t-1} + \varepsilon_t$, $\varepsilon_t \sim N(0,h)$. $LB^2(15)$ is the Ljung-Box statistics for the squared residuals from the regression for up to 15 days. ***, **, * represent 1%, 5% and 10% respectively.

Table 4.4 Two-Regime Model in Mean Equation with Constant Variance

	μ	ϕ	ω	θ	h	P11	P22	$LB^2(15)$	Log likelihood
Thailand	-0.081***	-0.066***	0.216***	0.170**	1.589***	0.832***	0.199***	302.62***	-6730.06
	0.264*	0.935***	0.784***	-0.180**		[6]	[1]		
Indonesia	0.018	-0.073**	0.135***	-0.030	1.282***	0.726***	0.249***	193.40***	-6021.51
	-0.103**	1.043***	0.491***	0.116**		[4]	[1]		
Malaysia	-0.008	0.239***	0.255***	-0.036	1.369***	0.955***	0.305***	1491.77***	-6131.95
	0.042	-0.599***	0.900***	-5.417***		[22]	[1]		
Philippines	0.007	0.037**	0.261***	-0.019	1.378***	0.863***	0.143***	46.63***	-6231.00
	-0.066	1.148***	0.537***	-1.218***		[7]	[1]		
Korea	-0.119***	0.018	0.396***	0.0004	1.772***	0.980**	0.381***	275.49***	-7074.60
	3.845***	-0.475***	2.101***	-1.323***		[50]	[2]		
Hong Kong	0.092***	-0.036**	0.540***	1.183	1.407***	0.991***	0.450**	289.60***	-6240.29
	-5.565	-0.575	1.628	-7.275		[111]	[2]		
Taiwan	0.042	-0.217***	0.264***	-0.206*	1.812***	0.771**	0.405***	989.59***	-7149.61
	-0.189*	0.595***	0.571***	-0.303		[4]	[2]		
Singapore	0.042	-0.101	0.305***	-0.139	1.108***	0.783*	0.272***	202.81***	-5490.29
	-0.181**	0.735***	0.823***	-0.109		[5]	[1]		
Japan	-0.046**	-0.048***	0.378***	-0.009	1.379***	0.992***	0.338***	432.93***	-6094.09
	-2.169***	-0.506***	4.192***	-0.664***		[125]	[2]		

Notes: Estimation results for Equation (4.2): $R_t = \mu_{S_t} + \phi_{S_t} R_{t-1} + \omega_{S_t} R_{t-1}^{US} + \theta_{S_t} X_{t-1} + \varepsilon_{S_t}$, $\varepsilon_{S_t} \sim N(0,h)$. P11 and P22 is the transition probabilities. h is the constant variance. $LB^2(15)$ is the Ljung-Box statistics for the squared standardized residuals for up to 15 days. Log likelihood is the function value achieved by the estimation. ***, **, * represent 1%, 5% and 10% respectively. Average number of days in each regime is calculated and shown in brackets.

Table 4.5 Two-Regime Model in Mean Equation with Different Variances

	μ	ϕ	ω	θ	h	P11	P22	$LB^2(15)$	Log likelihood
Thailand	-0.019	0.110***	0.169***	0.051	1.096***	0.967***	0.925***	669.02***	-6410.34
	-0.069	0.117***	0.635***	0.107	2.732***	[30]	[13]		
Indonesia	0.004	0.258***	0.135***	-0.013	0.662***	0.947***	0.876***	554.55***	-5273.44
	-0.021	0.178***	0.393***	0.005	2.500***	[19]	[8]		
Malaysia	0.009	0.200***	0.172***	0.106**	0.789***	0.966***	0.894***	1194.22***	-5464.55
	-0.053	0.014	0.675***	-0.390***	2.765***	[29]	[9]		
Philippines	-0.027	0.188***	0.181***	-0.067*	0.891***	0.965***	0.933***	146.33***	-5872.22
	0.031	0.152***	0.573***	-0.239***	2.295***	[29]	[15]		
Korea	-0.034	0.018	0.169***	0.009	1.143***	0.981***	0.972***	594.35***	-6693.13
	-0.001	0.006	0.654***	-0.151***	2.688***	[53]	[36]		
Hong Kong	0.073***	0.029	0.435***	0.922	0.983***	0.982***	0.956**	845.85***	-5893.94
	-0.123	-0.051	0.826***	2.001	2.409***	[56]	[23]		
Taiwan	-0.002	0.006	0.272***	-0.127	1.309***	0.980***	0.939***	1346.80***	-6781.77
	-0.094	0.036	0.547***	-0.497*	3.232***	[50]	[16]		
Singapore	-0.004	0.139***	0.322***	0.052	0.776***	0.973***	0.909***	445.84***	-5064.25
	-0.009	0.065***	0.574***	-0.516***	2.150***	[37]	[11]		
Japan	-0.044*	-0.066***	0.379***	0.069*	1.014***	0.982***	0.961***	221.64***	-5866.52
	-0.092	-0.060*	0.452***	-0.125	2.076***	[56]	[26]		

Notes: Estimation results for Equation (4.3): $R_t = \mu_{S_t} + \phi_{S_t} R_{t-1} + \omega_{S_t} R_{t-1}^{US} + \theta_{S_t} X_{t-1} + \varepsilon_{S_t}$, $\varepsilon_{S_t} \sim N(0, h_{S_t})$. P11 and P22 is the transition probabilities. $LB^2(15)$ is the Ljung-Box statistics for the squared standardized residuals for up to 15 days. Log likelihood is the function value achieved by the estimation. ***, **, * represent 1%, 5% and 10% respectively. Average number of days in each regime is calculated and shown in brackets.

Table 4.6 Likelihood Ratio Tests

Restricted Model	Equation (4.2)	Equation (4.4)	Equation (4.3)
Unrestricted Model	Equation (4.3)	Equation (4.3)	Equation (4.5)-(4.7)
Thailand	639.44***	3.62*	1596.94***
Indonesia	1496.14***	0.24	2034.34***
Malaysia	1334.80***	14.72***	1847.26***
Philippines	717.56***	4.04**	1700.98***
Korea	762.94***	7.10***	1514.96***
Hong Kong	692.70***	0.26	1432.66***
Taiwan	735.68***	1.06	1614.36***
Singapore	852.08***	12.22***	1476.18***
Japan	455.14***	3.72*	1245.58***

Notes: Likelihood ratio test statistic is $LR = -2*(L_r - L_u)$,where L_u and L_r are the maximized values of the (Gaussian) log likelihood function of the unrestricted and restricted regressions, respectively. Under the null that the additional parameters are not jointly significant, the LR statistic has an asymptotic distribution with degrees of freedom equal to the number of restrictions. For the second and the third columns, the critical values for $\chi^2(1)$ are 6.64, 3.84, and 2.71 at 1%, 5% and 10% level respectively. For the fourth column, the critical values for $\chi^2(4)$ are 13.277, 9.488, and 7.779 at 1%, 5% and 10% level respectively.

Table 4.7 Two-Regime Model in Mean Equation with Different Variances, but Constant Exchange Exposure

	μ	ϕ	ω	θ	h	P11	P22	$LB^2(15)$	Log likelihood
Thailand	-0.020	0.111***	0.169***	0.078	1.093***	0.966***	0.923***	680.61***	-6412.15
	-0.067	0.115***	0.632***		2.727***	[29]	[13]		
Indonesia	0.003	0.258***	0.136***	-0.004	0.660***	0.946***	0.877***	560.57***	-5273.56
	-0.020	0.177***	0.392***		2.497***	[19]	[8]		
Malaysia	0.006	0.195***	0.172***	-0.079	0.793***	0.967***	0.896***	1196.86***	-5471.91
	-0.054	0.043	0.694***		2.786***	[30]	[10]		
Philippines	-0.025	0.188***	0.181***	-0.112***	0.892***	0.965***	0.933***	128.27***	-5874.24
	0.026	0.159***	0.573***		2.301***	[29]	[15]		
Korea	-0.033	0.016	0.168***	-0.098***	1.141***	0.981***	0.972***	622.58***	-6696.68
	-0.003	0.012	0.652***		2.683***	[53]	[36]		
Hong Kong	0.072***	0.029	0.434***	1.059*	0.984***	0.983***	0.958**	875.98***	-5894.07
	-0.122	-0.052	0.827***		2.409***	[59]	[24]		
Taiwan	-0.003	0.004	0.273***	-0.162*	1.307***	0.980***	0.940***	1379.42***	-6782.30
	-0.097	0.040	0.540***		3.220***	[50]	[17]		
Singapore	-0.005	0.138***	0.324***	-0.046	0.782***	0.974***	0.907***	460.98***	-5070.36
	-0.014	0.079***	0.579***		2.191***	[38]	[11]		
Japan	-0.043*	-0.067***	0.382***	0.026	1.008***	0.982***	0.962***	227.75***	-5868.38
	-0.090	-0.055*	0.451***		2.064***	[56]	[26]		

Notes: Estimation results for Equation (4.4): $R_t = \mu_{S_t} + \phi_{S_t} R_{t-1} + \omega_{S_t} R_{t-1}^{US} + \theta X_{t-1} + \varepsilon_{S_t}$, $\varepsilon_{S_t} \sim N(0, h_{S_t})$. P11 and P22 is the transition probabilities. h is the constant variance. $LB^2(15)$ is the Ljung-Box statistics for the squared standardized residuals for up to 15 days. Log likelihood is the function value achieved by the estimation. ***, **, * indicates 1%, 5% and 10% respectively. Average number of days in each regime is calculated and shown in brackets.

Table 4.8 Two-Regime GARCH (1,1) Model

	μ	ϕ	ω	θ	λ	α	β	$\frac{\lambda}{1-\alpha-\beta}$	P11	P22	$LB^2(15)$	Log likelihood
Thailand	-0.128**	1.043***	0.041	-0.093*	0.141***	0.349***	0.000***	0.217	0.140***	0.763***	163.50***	-5616.87
	0.003	0.183***	0.128***	0.045**	0.560***	0.134***	0.022***	0.664	[1]	[4]		
Indonesia	0.002	0.982***	0.001	-0.020	-0.0001	0.516***	0.085***	0.000	0.464***	0.158***	305.27***	-4256.27
	-0.005	0.239***	0.103***	-0.013	0.343***	0.183***	0.015*	0.428	[2]	[1]		
Malaysia	-0.016**	0.314***	0.107***	-0.004	0.269***	0.249***	0.062***	0.390	0.982**	0.904***	775.95***	-4540.92
	-0.100	0.549***	0.292***	-0.224*	0.986	0.132***	0.019***	1.161	[56]	[10]		
Philippines	-0.0004	0.964***	0.026	0.002	0.107***	0.397***	0.012	0.181	0.297***	0.893***	194.40***	-5021.73
	-0.017	0.225***	0.149***	-0.058*	0.425***	0.180***	0.030***	0.538	[1]	[9]		
Korea	0.038	0.992***	0.038	-0.011	0.163***	0.331***	0.006	0.246	0.146***	0.758***	246.70***	-5935.65
	-0.035	0.123***	0.144***	0.021	0.616***	0.122***	0.012***	0.711	[1]	[4]		
Hong Kong	-0.162***	0.792***	0.131**	0.383	0.183***	0.353***	0.064***	0.314	0.341***	0.733***	224.04***	-5177.61
	0.082**	0.037**	0.286***	0.602	0.502***	0.138***	0.006*	0.586	[2]	[4]		
Taiwan	-0.010	0.959***	0.156**	0.072	0.226***	0.299***	0.020***	0.332	0.117***	0.655***	219.19***	-5974.59
	-0.022	0.068***	0.134***	-0.128**	0.619***	0.112	0.014***	0.708	[1]	[3]		
Singapore	-0.048	0.841***	0.203***	0.071	0.129**	0.409***	0.045	0.236	0.277**	0.747**	202.98***	-4326.16
	-0.004	0.141***	0.184***	-0.068	0.391***	0.178***	0.018	0.486	[1]	[4]		
Japan	0.171***	0.639***	-0.071	0.062	0.140***	0.354***	0.098***	0.255	0.208***	0.714***	144.70***	-5243.73
	-0.126***	0.031	0.379***	-0.009	0.553***	0.132***	0.006**	0.642	[1]	[3]		

Notes: Estimation results for equation (4.3): $R_t = \mu_{S_t} + \phi_{S_t} R_{t-1} + \omega_{S_t} R^{US}_{t-1} + \theta_{S_t} X_{t-1} + \varepsilon_{S_t}$, and equations (4.5)-(4.7): $h_{S_t,t} = \lambda_{S_t} + \alpha_{S_t}\varepsilon^2_{t-1} + \beta_{S_t} h_{t-1}$, $h_{t-1} = p_{1t-1}[\tau^2_{1t-1} + h_{1t-1}] + (1-p_{1t-1})[\tau^2_{2t-1} + h_{2t-1}] - [p_{1t-1}\tau_{1t-1} + (1-p_{1t-1})\tau_{2t-1}]^2$, $\varepsilon_{t-1} = R_{t-1} - [p_{1t-1}\tau_{1t-1} + (1-p_{1t-1})\tau_{2t-1}]$. τ_{1t} and τ_{2t} are the conditional means of the stock return in the two regimes respectively. p_{1t} is the conditional probability of being in regime 1 at time t. The other notes are same as Table 4.4.

Appendix B: Figures

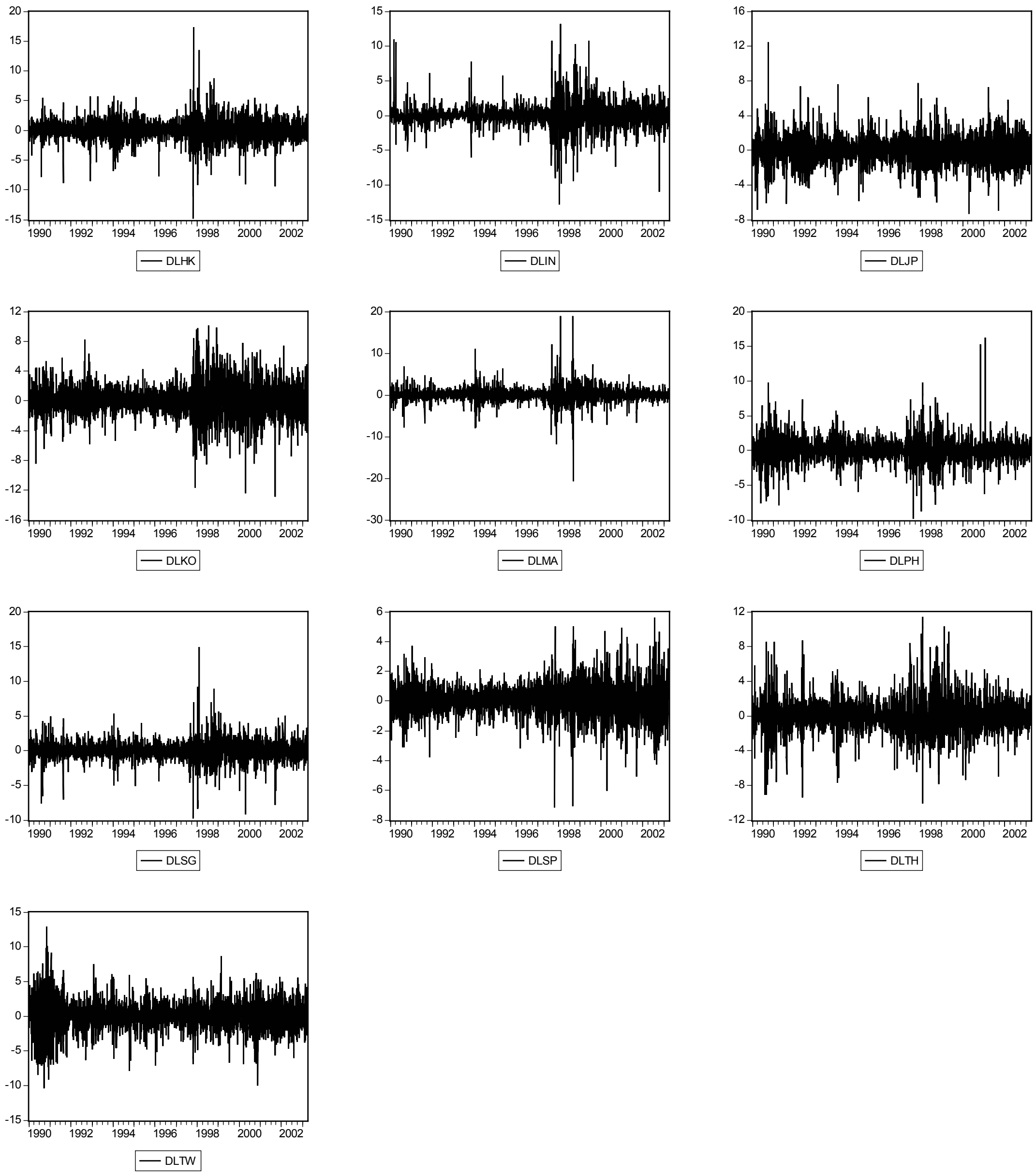


Figure 2.1 Daily Stock Returns (1/1/1990-3/21/2003)

DLHK, DLIN, DLJP, DLKO, DLMA, DLPH, DLSG, DLSP, DLTH, and DLTW represent the stock returns of Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, the U.S., Thailand, and Taiwan. DL represents the log difference of the stock indices.

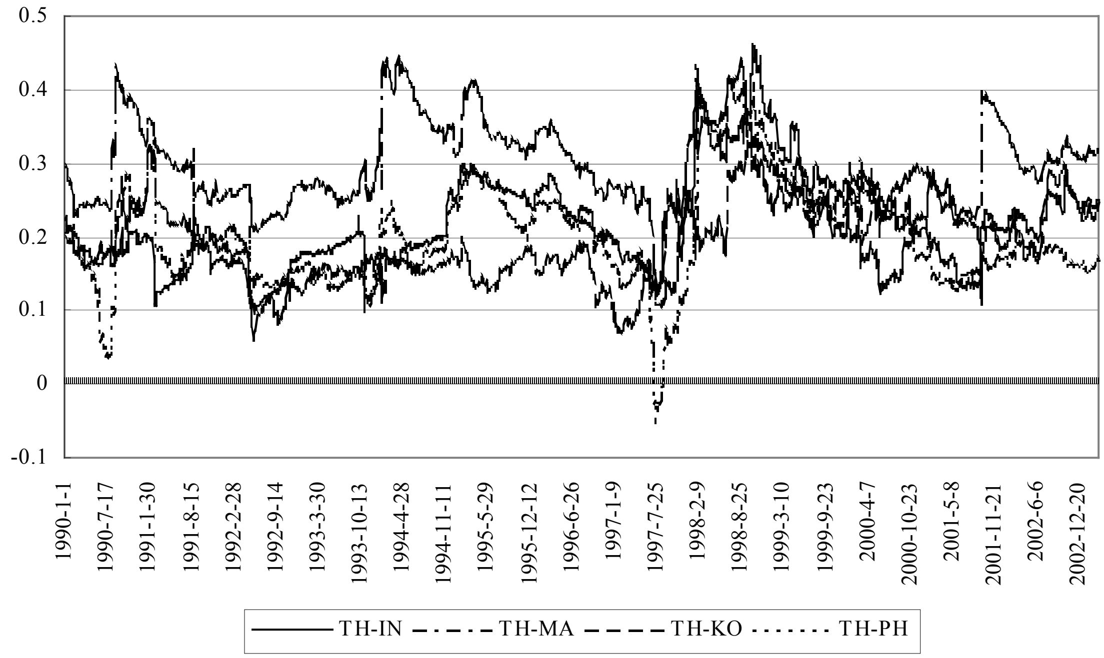


Figure 2.2a GARCH-Corrected Correlations between the Stock Return of Thailand and Those of the Other Four Crisis Countries (1990-2003)

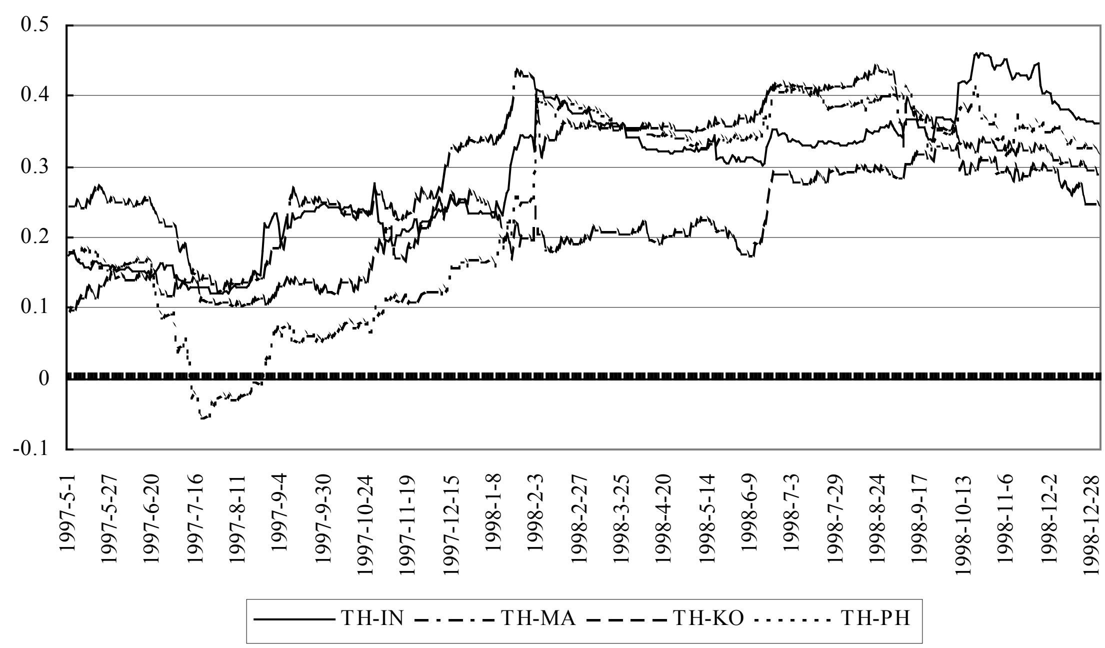


Figure 2.2b GARCH-Corrected Correlations between the Stock Return of Thailand and Those of the Other Four Crisis Countries (1997-1998)

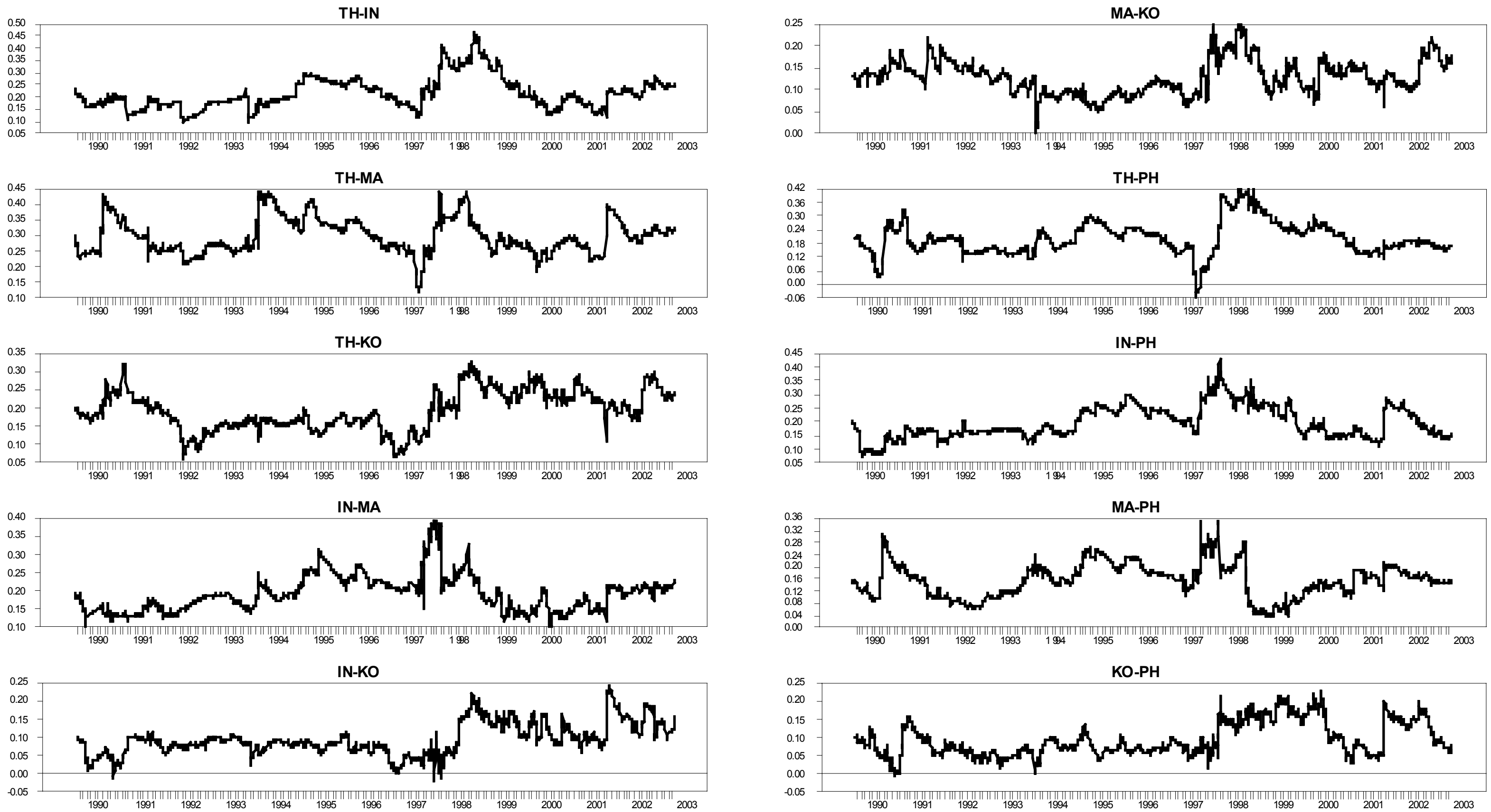


Figure 2.2c Pair-wise GARCH-Corrected Correlations between the Stock Returns of Five Hardest Hit Crisis Countries (1990-2003)

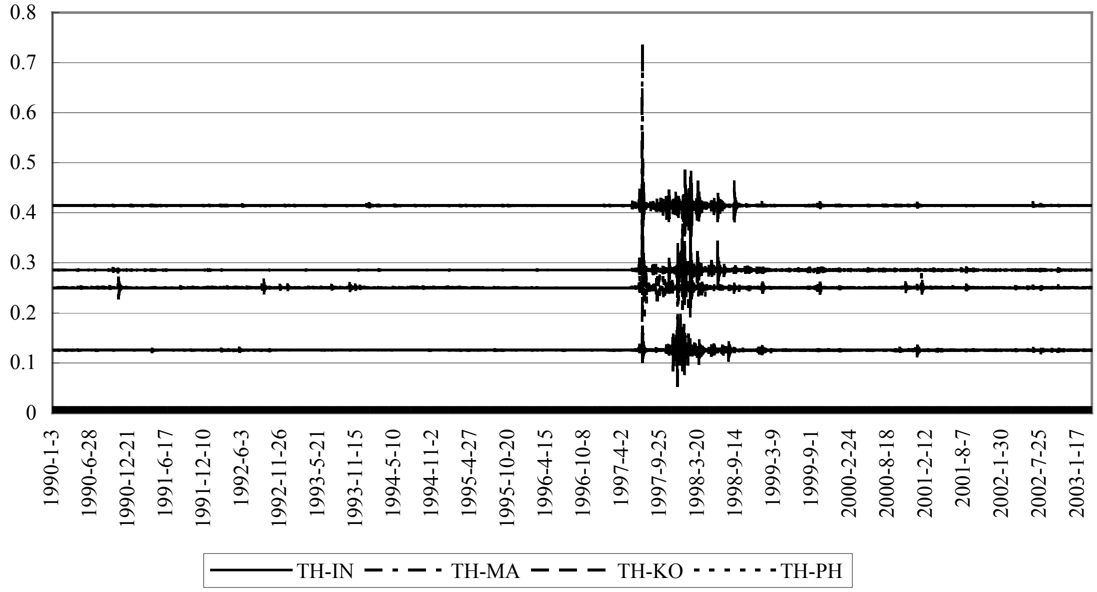


Figure 2.3a GARCH-Corrected Correlations between Exchange Rates in Thailand and Those of the Other Four Crisis Countries (1990-2003)

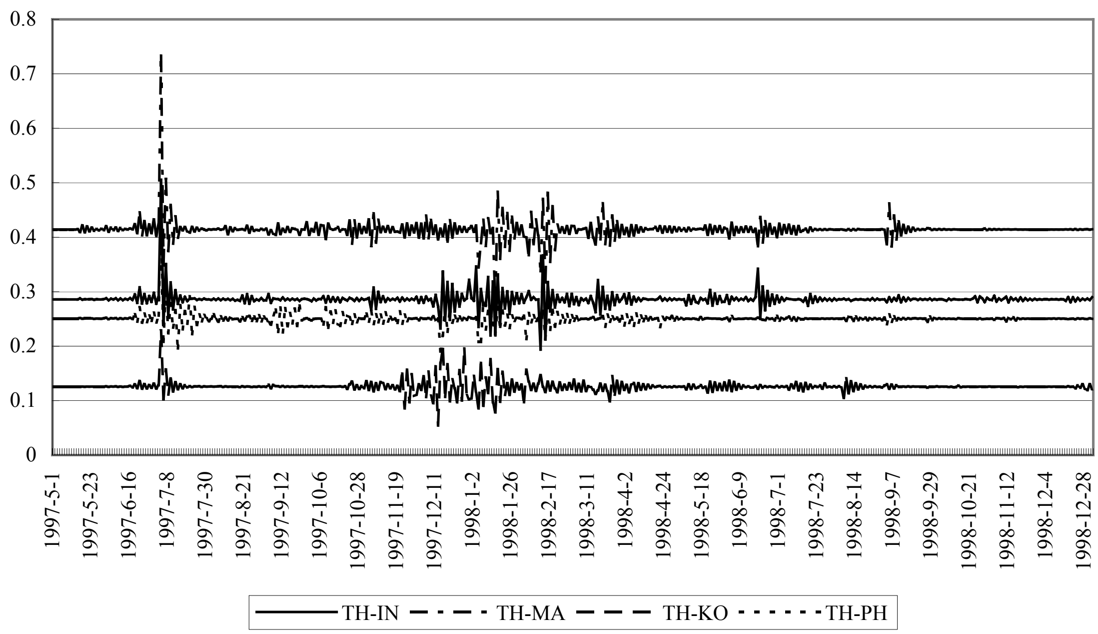


Figure 2.3b GARCH-Corrected Correlations between Exchange Rates in Thailand and Those of the Other Four Crisis Countries (1997-1998)

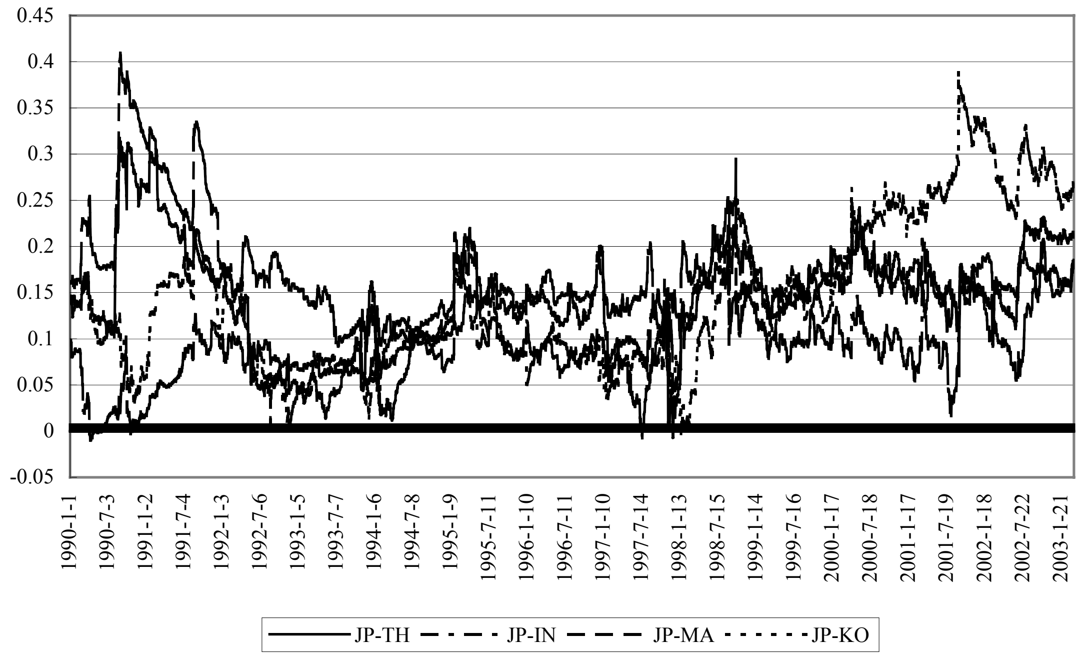


Figure 2.4a GARCH-Corrected Correlations between the Stock Return of Japan and Those of the Other Four Crisis Countries (1990-2003)

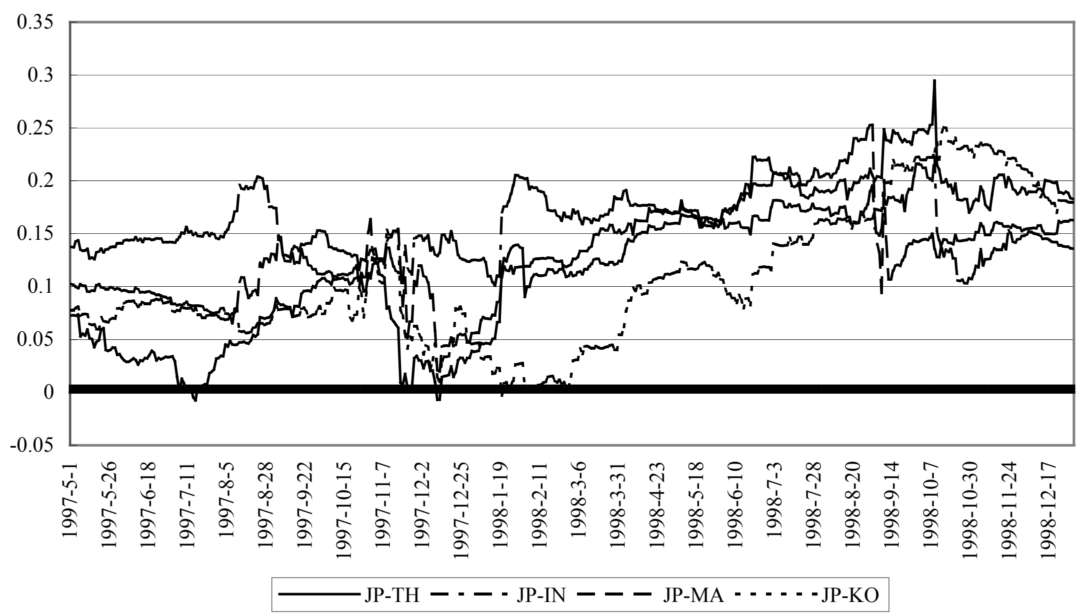


Figure 2.4b GARCH-Corrected Correlations between the Stock Return of Japan and Those of the Other Four Crisis Countries (1997-1998)

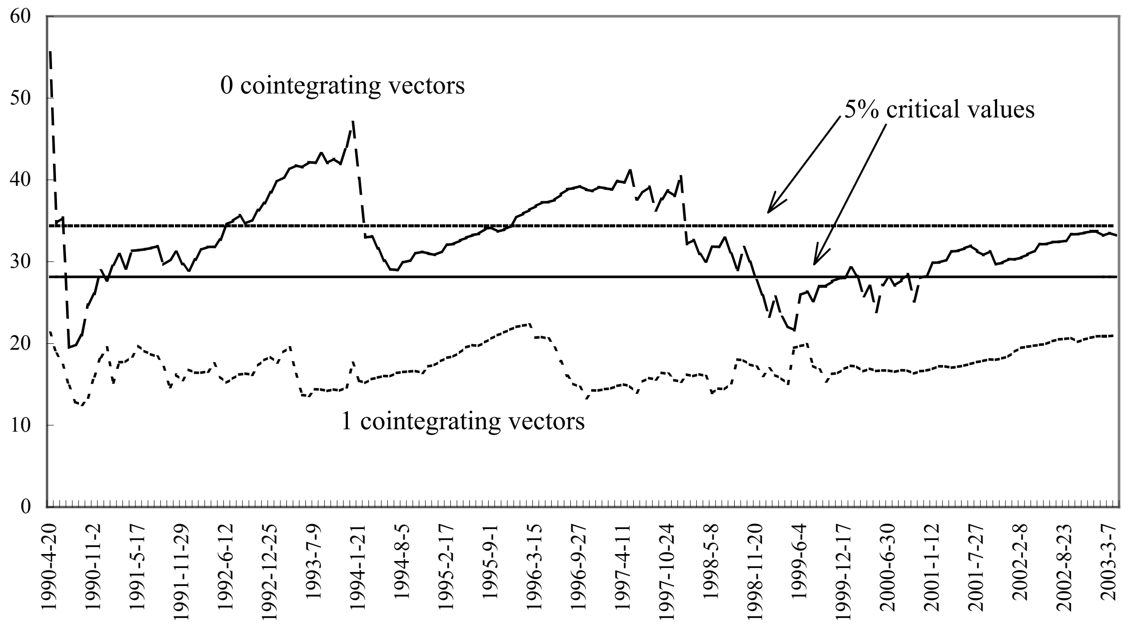


Figure 2.5a Iterated Maximum Eigenvalue Statistics

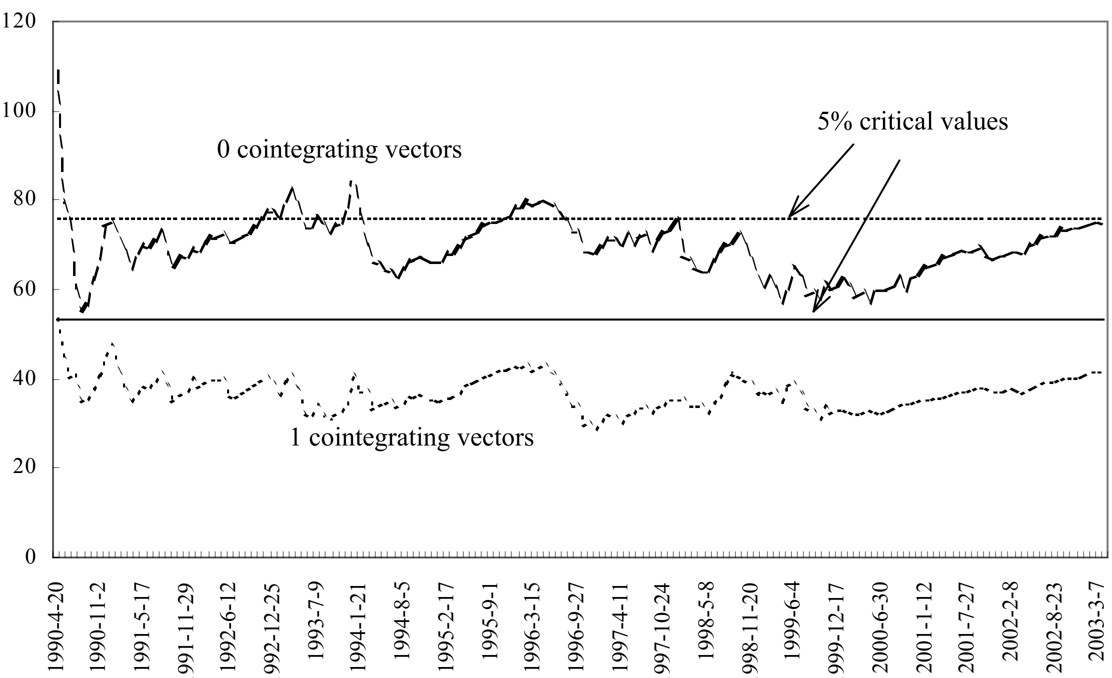


Figure 2.5b Iterated Trace Statistics

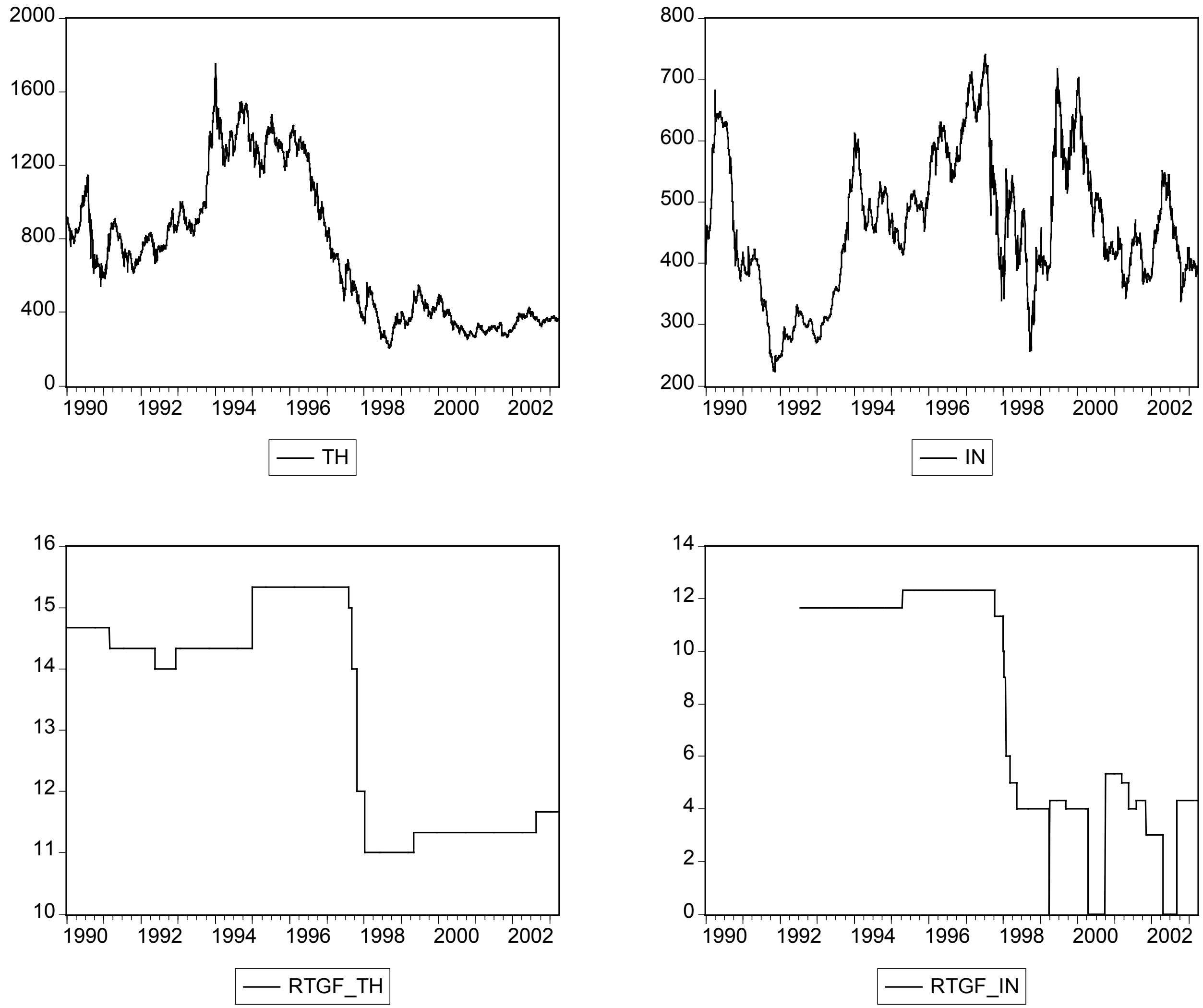


Figure 3.1 Ratings and Stock Indices (1/1/1990-3/21/2003)

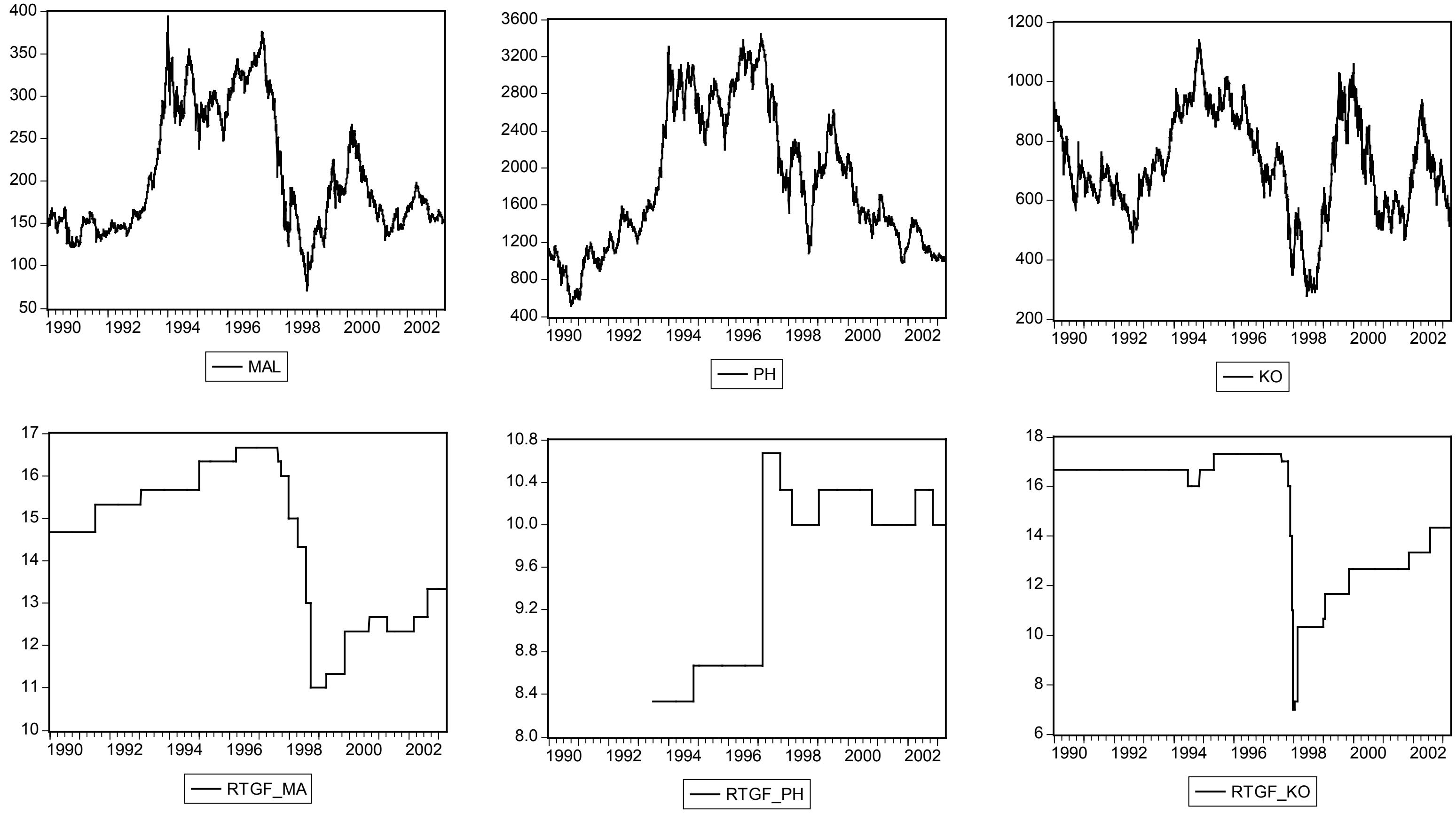


Figure 3.1 Ratings and Stock Indices (1990-2003) (Continued)

TH, IN, MAL, PH, and KO represent the stock indices in Thailand, Indonesia, Malaysia, the Philippines and Korea respectively. RTGF_TH, RTGF_IN, RTGF_MA, RTGF_PH, and RTGF_KO represent the ratings in corresponding countries.

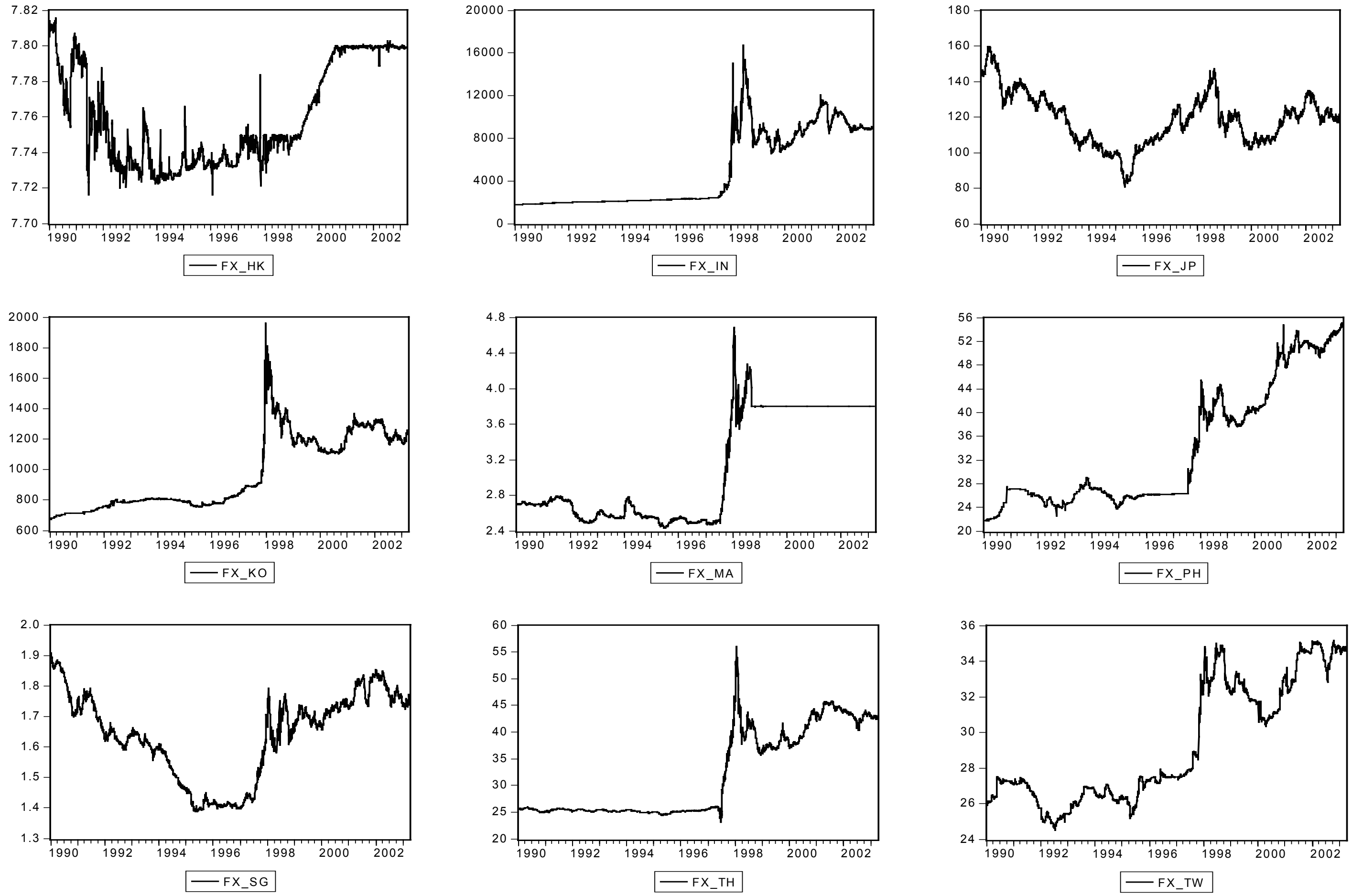


Figure 4.1 Exchange Rates (vs. US Dollar) in Nine Asian Markets (1/1/1990-3/21/2003)

FX_HK, FX_IN, FX_JP, FX_KO, FX_MA, FX_PH, FX_SG, FX_TH, and FX_TW represent the bilateral exchange rates in terms of local currency per U.S. dollar in Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Thailand, and Taiwan.

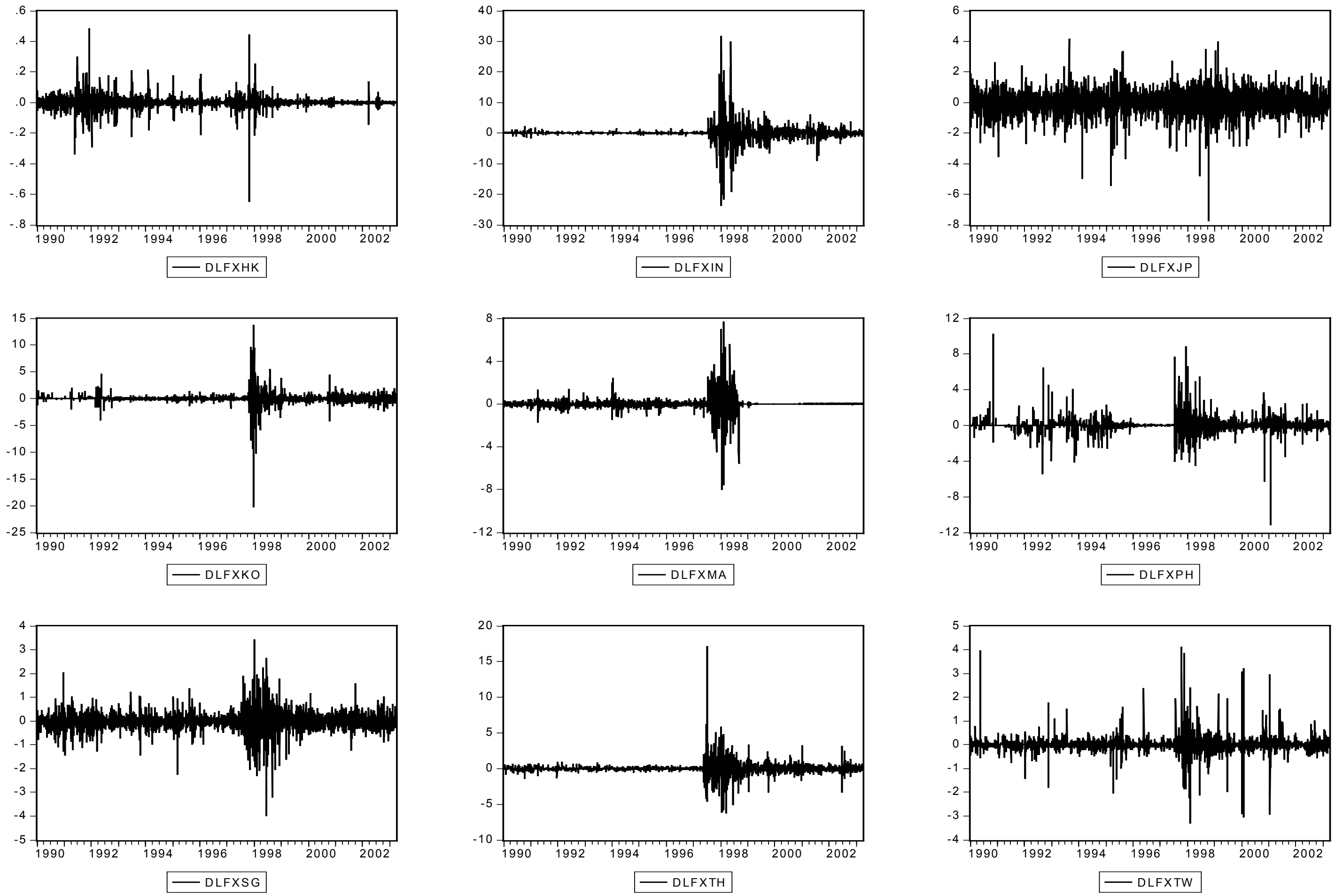


Figure 4.2 Exchange Rate Changes in Nine Asian Market (1/1/1990-3/21/2003)

DLFXHK, DLFXIN, DLFXJP, DLFXKO, DLFXMA, DLFXPH, DLFXSG, DLFXTH, and DLFXTW represent the bilateral exchange rate changes (first differences in natural logs) in Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Thailand, and Taiwan.

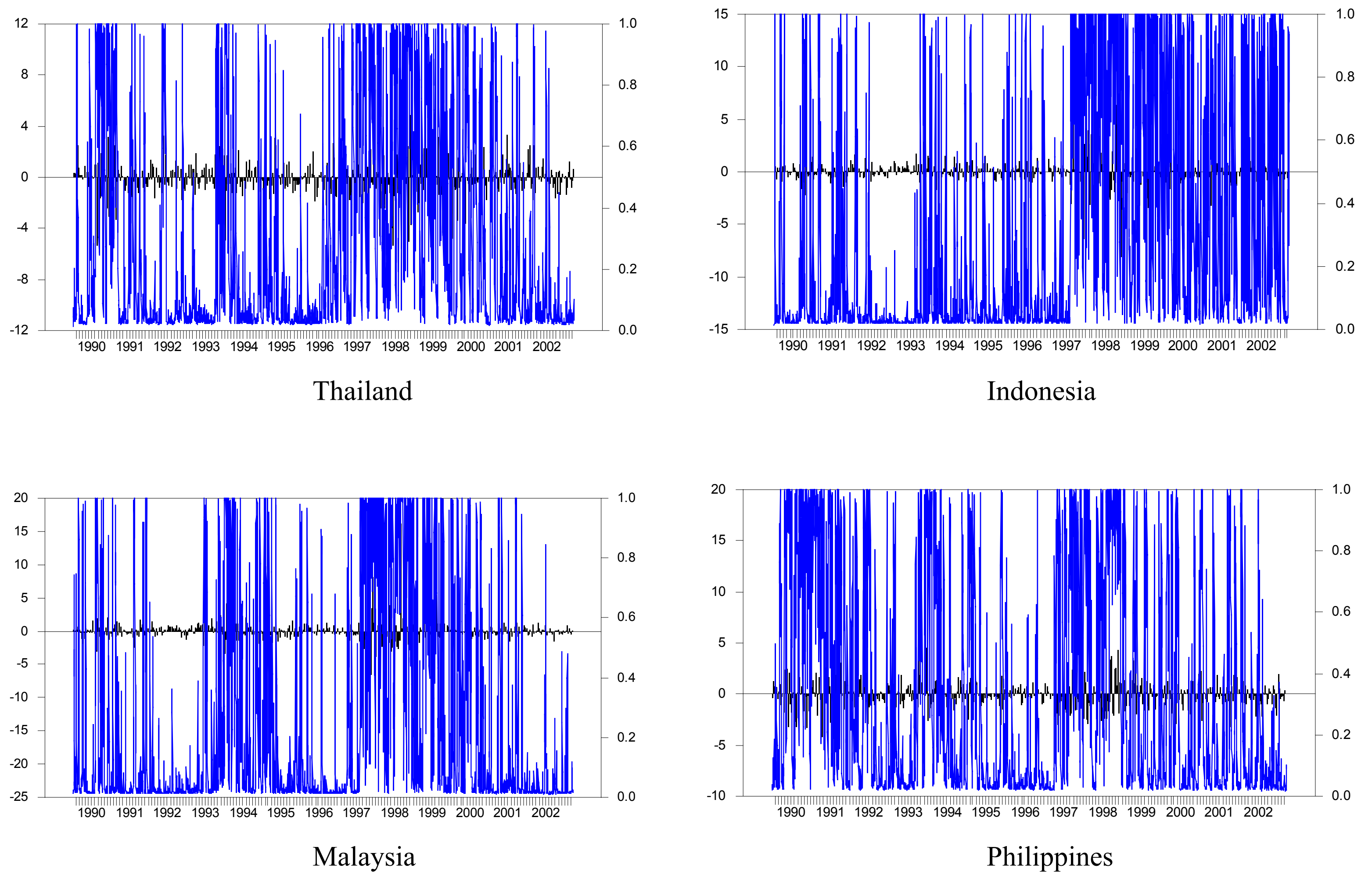
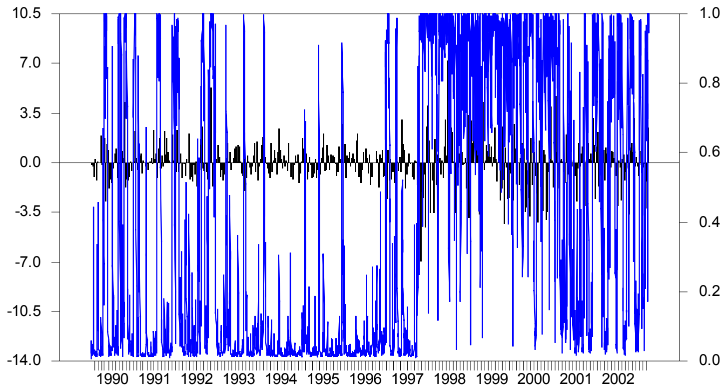
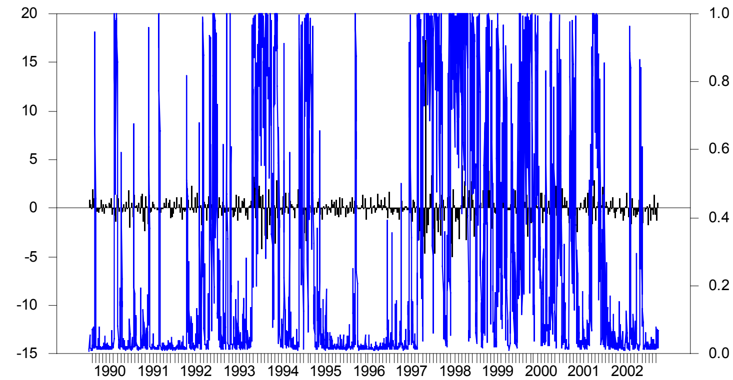


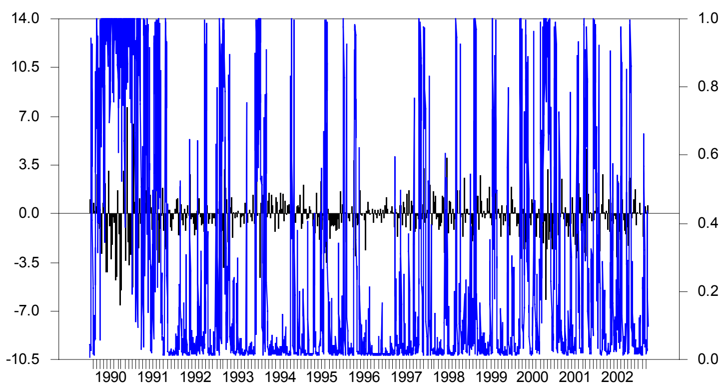
Figure 4.3 Stock Returns and Conditional Probabilities of Being in "High Volatility" Regime



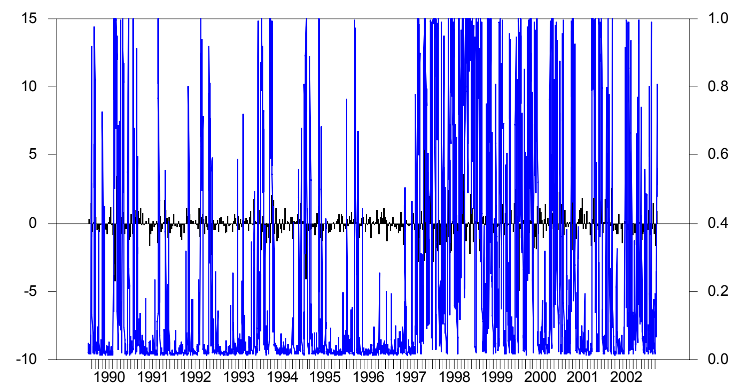
Korea



Hong Kong

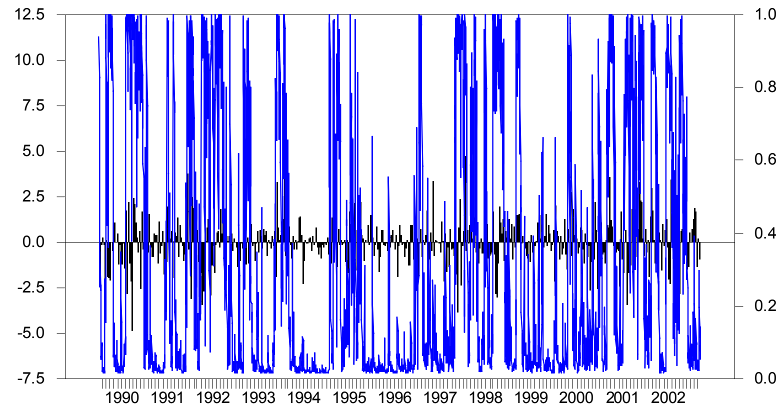


Taiwan



Singapore

Figure 4.3 Stock Returns and Conditional Probabilities of Being in "High Volatility" Regime (Continued)



Japan

Figure 4.3 Stock Returns and Conditional Probabilities of Being in "High Volatility" Regime (Continued)

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